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AD-P003 364

DRAG COEFFICIENTS
FOR
IRREGULAR FRAGMENTS

by

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The Naval Surface Weapons Center (NSWC) has a continuing task from the Department of Defense Explosive Safety Board (DDESB) to establish methods for predicting the fragment hazards due to the inadvertant explosion of ordnance items. As part of this task, NSWC has established a computer model which predicts fragment hazards. This computer model was explained in the minutes of the twenty-first DOD Explosives Seminar.

The computer model calculates individual trajectories for each fragment recovered in small-scale fragment arena tests. The following variables affect the individual fragment trajectories:

EI - Initial Elevation Angle
VI - Initial Velocity
A/M - Area to Mass Ratio
ALT - Altitude
RHO - Air Density
MN - Mach Number
HO - Height of the Origin
SC - Soil Constant (Ricochet)
W - Wind Speed and Direction
C_D - Drag Coefficient

Except for C_D, all of these variables can be defined with a fair degree of accuracy by tests, measurements, and calculations.

The drag coefficient for any fragment is a function of shape only. For regular fragments, like spheres or cubes, the drag coefficients are reasonably well defined. For irregular fragments, like those from bombs or concrete walls, no two fragments have exactly the same shape. As a result, no two irregular fragments have exactly the same drag coefficient. In all cases, drag coefficient is a function of Mach Number.

The drag coefficients for irregular fragments are not only uncertain but have a pronounced effect on far-field range. Figure 1 shows range versus C_D for a typical fragment. The range of low subsonic C_D varies from .5 to 1.5, a factor of three. Associated range varies by a factor of more than 2. This represents a large range uncertainty in trajectory calculations for establishing fragment hazards. If this uncertainty is to be reduced, some correlation must be established between C_D and the characteristics of the irregular fragments.

C_D is a function of shape only. Therefore any correlating parameter should be dimensionless; that is, geometrically similar fragments which have the same C_D should have the same correlating parameter. For example, we might take the ratio of the maximum presented area to the minimum presented area as a measure of shape. For a sphere this ratio would always be one no matter what the size of the sphere. For a cube this ratio would always be 1.732.

The impetus for this program was provided by an observation having to do with the data contained in reference (a). That report contained the first systematic look at air drag for fragments. Three regular fragments were studied in the report, i.e., a sphere, a cube and a bar. The bar length,

width and thickness were in the ratio of 5-1-1. Since these fragments were regular, exact ratios of maximum to minimum precented area could be calculated. The results were as follows:

	FRAGMENT SHAPE		
	SPHERE	CUBE	BAR (5-1-1)
C_D (MN .75)	.60	.88	1.12
A_{MAX}/A_{MIN}	1.00	1.73	7.14

Note that as the correlation ratio increases so does the C_D. The report also showed that the C_D for irregular fragments was greater than those for the sphere or cube. For irregular fragments the area ratio could be expected to be on the order of that for the bar. Everything seemed to support the idea that the C_D for irregular fragments could be correlated with dimensionless parameters.

To follow up on this idea, it was decided to choose 96 fragments with a wide variation of shapes for test in the vertical wind tunnel at Ballistic Research Laboratory (BRL) in Aberdeen, Maryland. Four different kinds of measurement were made on each fragment.

1. Linear Maxima: Length, width and thickness
2. Linear Averages: Length, width and thickness
3. Perimeters: (3 planes)
4. Presented Areas
    a. Maximum
    b. Average
    c. Minimum
    d. Variance
    e. Standard Deviation

Linear dimensions were measured as shown in Figure 2. Note that in calculating average dimensions, the average thickness is calculated to produce an equivalent weight and volume rectangular parallelepiped.

Perimeters were measured in three planes as shown in Figure 3. Note that the perimeters do not exactly follow the contour of the fragment but represent a stretched string around the high points.

Fragment presented areas were measured in two ways. Measurements were made using an icosahedron gage, and calculations were performed on the equivalent weight and volume rectangular parallelepipeds. Figures 4 and 5 show the essentials of these measurements and calculations. The icosahedron gage is an optical device which throws a shadow of the fragment onto a sensing surface. The associated electronics produces a readout of presented area. The optical axis is positioned at 16 approximately equally spaced aspects so as to produce 16 distinct presented areas which can be analysed for a variety

of statistics. The icosahedron gage cannot mount a fragment weighing more than 1500 grains. For larger fragments, presented area statistics are calculated using the rectangular parallelepipeds as shown in Figure 5.

All of the linear, perimeter and area measurements for the 96 fragments are contained in Tables A-1, A-2 and A-3 of Appendix A.

The essential aspects of the vertical wind tunnel are shown in Figure 6. In operation, a fragment is placed on the fragment support screen in either the upper or lower test section depending on the air velocity necessary to raise the fragment. The air speed is controlled by opening the inlet vanes of the constant speed fan. The air speed is adjusted until the fragment rises from the screen and assumes a relatively constant height. At this time, the air stream velocity is read directly from the velocity calibrated manometer. Air density is calculated from the ambient pressure and temperature. Ambient conditions are acceptable because of the relatively low air velocities produced in the tunnel. These parameters together with the weight and average presented area of the fragment are then used to calculate the low subsonic drag coefficient (C_D).

Each fragment was tested in the vertical wind tunnel. The velocity of the air stream is increased until the fragment hovers in the air stream at near constant vertical height. In this vertical equilibrium position the drag and gravity forces will also be in equilibrium. From previous measurements we know the weight and average presented area of the fragment. From the wind tunnel we establish the density and velocity of the air stream. As shown in Figure 7, once we know these values, we can calculate C_D. Since we operate at a single air velocity we can only obtain a single point on the drag curve. This point is in the low subsonic region, roughly about a Mach Number of 0.1. The remainder of the drag curve must be inferred from other sources.

Three regular fragments (sphere, cube and bar) which were tested in reference (a) were also tested in the vertical wind tunnel. In reference (a) however, C_D was obtained at a Mach Number of approximately .75. The results were as follows:

	C_D Wind Tunnel	C_D Reference (a)	Delta
Sphere	.42	.60	+ .18
Cube	.64	.88	+ .24
Bar	.94	1.12	+ .18

As seen in the table, C_D at Mach .75 is about .2 higher than C_D at Mach .1 for all three fragments. Owing to the consistancy in the rise of C_D from Mach .1 to Mach .75 for the three regular fragments, it seems reasonable at this time to accept the same rise in C_D for irregular fragments. In this way, the shape of the subsonic drag curve (as a function of Mach Number) for irregular fragments is established.

Experience shows that range is more sensitive to changes in subsonic C_D than to similar changes in supersonic C_D. This can best be seen in Figures 8 and 9. The shape of the transonic and supersonic portions of the drag curves in Figure 8 are approximations based on the study of scattered data in

reference (a) and (b). On the left side of Figure 8, the subsonic C_D is held constant while the supersonic C_D is allowed to vary ±.25 about the mean. The range differences from the mean are both less than 100 feet. On the right side of Figure 8, the supersonic C_D is kept about the same as before and the subsonic C_D is allowed to vary ±.25 about the mean. If subsonic and supersonic C_D were equally sensitive then the new range differences (deltas) should be about twice what they were before. In fact, they are about four times as large.

This range sensitivity can be further explained by the data in Figure 9 where velocity is plotted against range ratio for a typical far-field trajectory. The range ratio is the fraction of the total trajectory traversed. From the figure it can be seen that only 25 percent of the trajectory is supersonic while 75 percent is subsonic. Figures 8 and 9 demonstrate that the subsonic portion of the drag curve affects range much more than the supersonic portion.

Tables A-4, A-5 and A-6 of Appendix A list all of the dimensionless ratios considered to date. When plots of C_D versus the ratios were made, the best correlation was obtained with the ratio A_{MAX}/A_{AVG}: that is, the ratio of the maximum presented area to the average presented area. This correlation is shown on Figure 10 The value for A_{MAX}/A_{AVG} is an average of the values obtained using the icosahedron gage and the equivalent rectangular parallelepiped calculations. The total range of uncertainty for all irregular fragments is from about 0.5 to 1.5. The range of C_D uncertainty at an average A_{MAX}/A_{AVG} of 1.45 to 1.5 is about 0.6. On average then, it can be said that the correlation reduces the uncertainty by about 40 percent.

It is important to know what a 40 percent reduction in C_D uncertainty means in terms of range uncertainty. Figure 11 shows this range uncertainty for a typical fragment trajectory with a presented area ratio of 1.5. The range differences are large, about 18 percent above the average and 28 percent below. In order to reduce the range uncertainty to an acceptable region of about ±10 percent, it will be necessary to reduce the C_D uncertainty by about 75 percent.

In summary, the following observations can be made:

1. C_D is a function of shape only.

2. Range is more sensitive to subsonic than to supersonic C_D variations.

3. C_D correlates with dimensionless parameters.

4. The A_{MAX}/A_{AVG} parameter correlation reduces C_D uncertainty by approximately 40 percent.

Significant problems remain unresolved. For an acceptable range uncertainty of about ±10 percent, it will be necessary to reduce the C_D uncertainty by about 75 percent. This might be done in a variety of ways. More efficient correlation parameters might be established. The typical motion of the fragments in the wind tunnel (Figure A-1 thru A-9 of Appendix A) might be used as an added correlation. Possibly, the use of presented area

other than average might be used in calculating C_D. For example, in Figure A-3 of Appendix A all fragments exhibit a flat rotation such that the area presented to the air stream is much greater than the average presented area.

Another unresolved problem involves the shape of the transonic and supersonic portions of the drag curve. At present, the shape is only an approximation based on scattered data contained in references (a) and (b). A practical method is needed to test irregular fragments for C_D in a supersonic wind tunnel. The essential problem is the design of a fixture which will allow the fragment to move freely and, at the same time, continually measure drag force.

REFERENCES

a) Air Drag Measurements of Fragments, D. J. Dunn, Jr., and W. R. Porter, BRL Memorandum Report No. 915, D. J. Dunn, Jr., and W. R. Portor, (UNCLASSIFIED, August 1955).

b) Subsonic, Transonic and Supersonic Drag Characteristics of Nine Shape Categories of Warhead Fragments, NSWC TR 81-112, Peter Daniels et al., (UNCLASSIFIED, May 1981)

C_D - RANGE SENSITIVITY

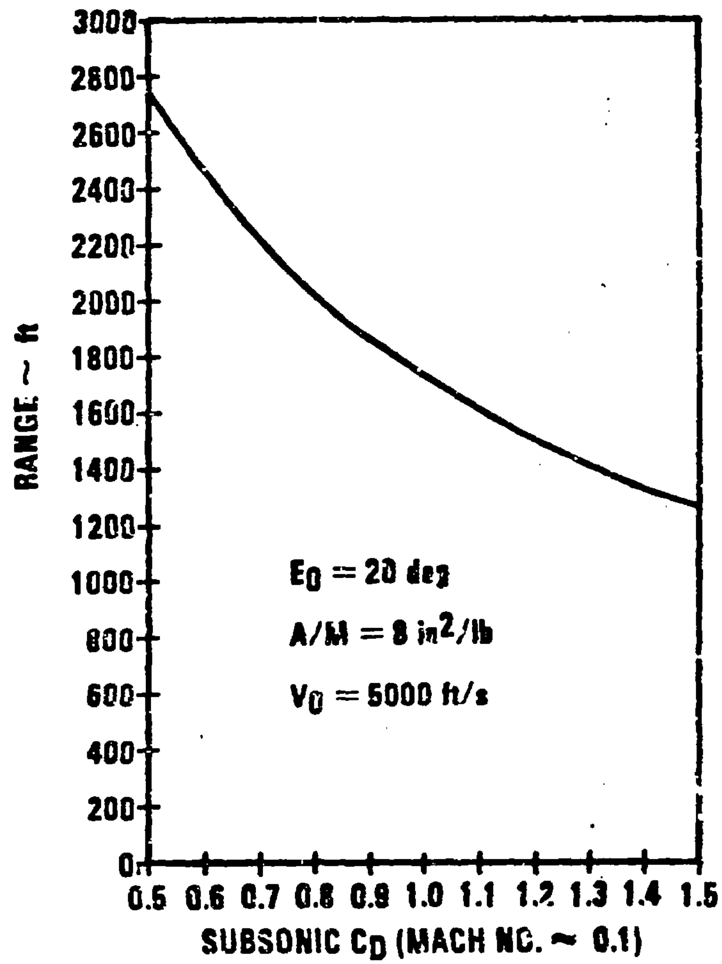
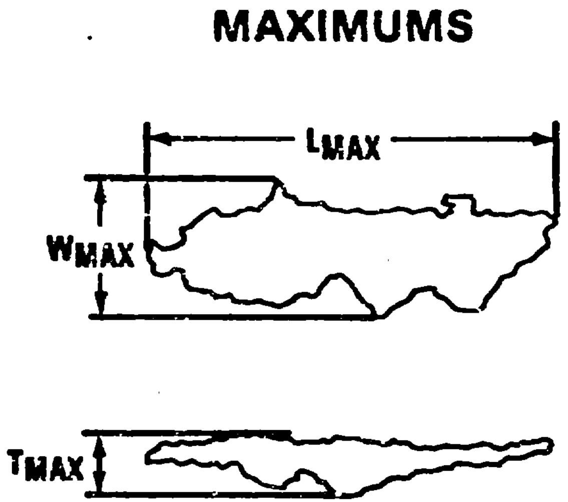
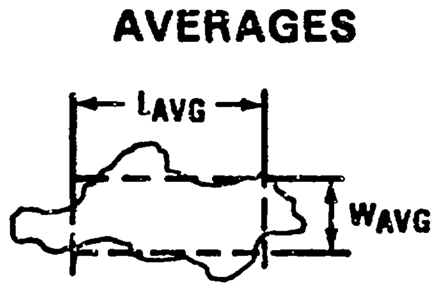


FIGURE 1

FRAGMENT LINEAR DIMENSIONS





FOR EQUIVALENT WEIGHT AND VOLUME

$$T_{AVG} = \frac{WT}{L_{AVG} \cdot W_{AVG} \cdot \rho}$$

WT = FRAG WEIGHT (lb)

L_{AVG} = AVERAGE LENGTH (in.)

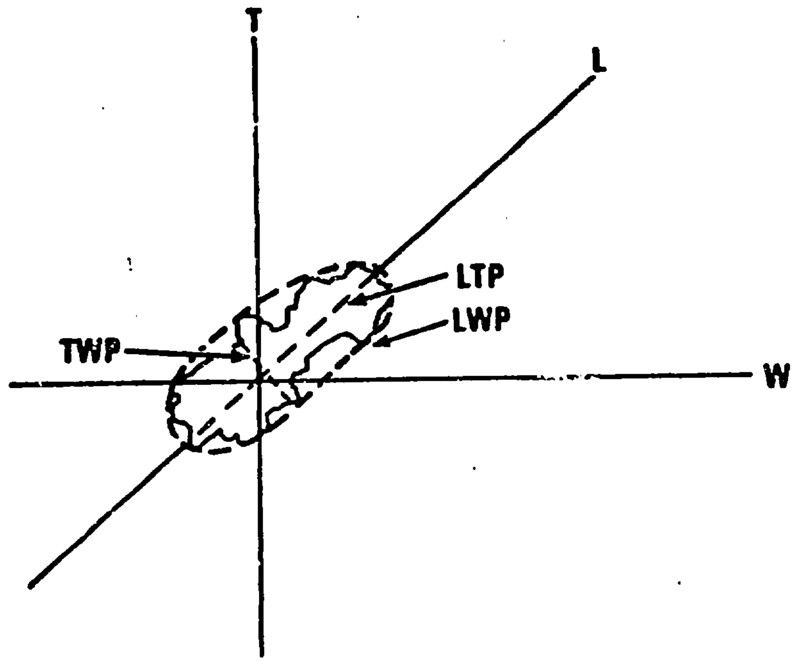
W_{AVG} = AVERAGE WIDTH (in.)

ρ = FRAG DENSITY (lb/in.^{3})

ρ = 0.28 (STEEL)

FIGURE 2

PERIMETER MEASUREMENTS



LWP - PERIMETER IN L-W PLANE

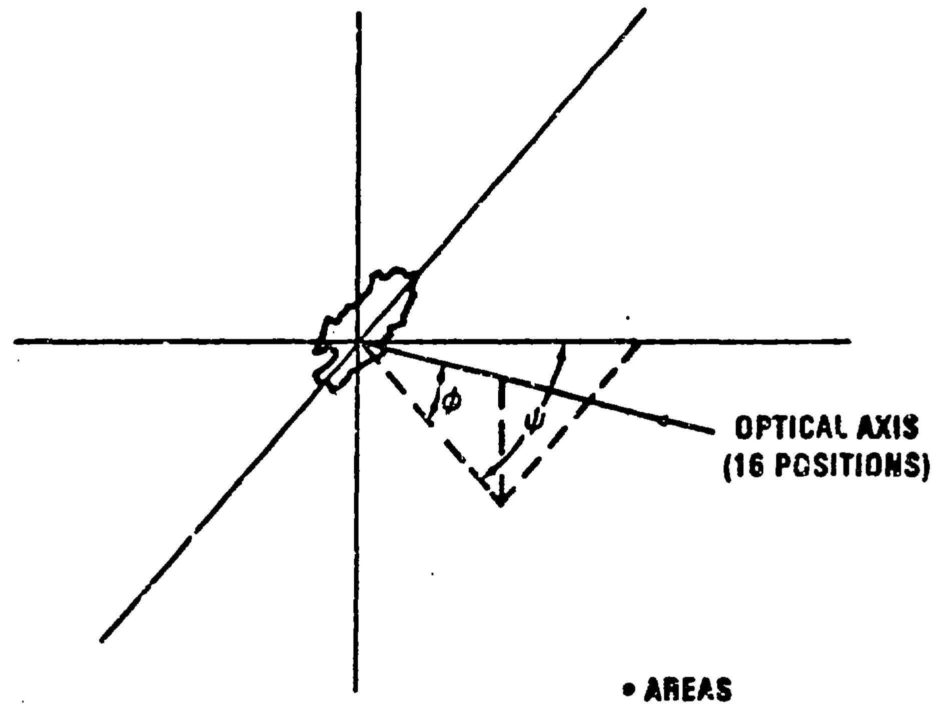
LTP - PERIMETER IN L-T PLANE

TWP - PERIMETER IN T-W PLANE

FIGURE 3

PRESENTED AREA MEASUREMENTS

(ICOSAHEDRON GAGE)

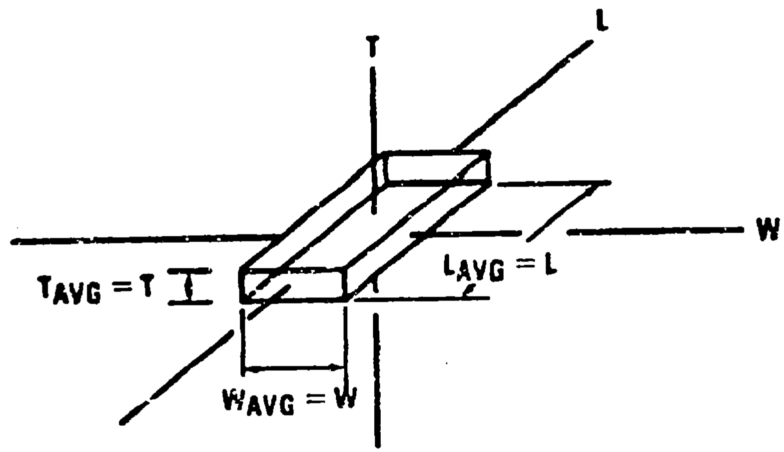


- AREAS
  - MINIMUM
  - AVERAGE
  - MAXIMUM
  - VARIANCE
  - STANDARD DEVIATION

FIGURE 4

PRESENTED AREA MEASUREMENTS

(EQUIVALENT WEIGHT AND VOLUME RECTANGULAR PARALLELEPIPED)



AREAS

MINIMUM $= W \cdot T$

AVERAGE $= 0.5\,(L \cdot W + L \cdot T + W \cdot T)$

MAXIMUM $= ((L \cdot W)^2 + (T \cdot L)^2 + (T \cdot W)^2)^{1/2}$

VARIANCE $= 1/12\left[(L \cdot T)^2 + (W \cdot T)^2 + (L \cdot W)^2\right] + \left[4/3\pi - 1/2\right] \cdot \left[L \cdot W \cdot (T)^2 + T \cdot W \cdot (L)^2 + T \cdot L \cdot (W)^2\right]$

STANDARD DEVIATION $= (\text{VARIANCE})^{1/2}$

FIGURE 5

SUBSONIC VERTICAL WIND TUNNEL

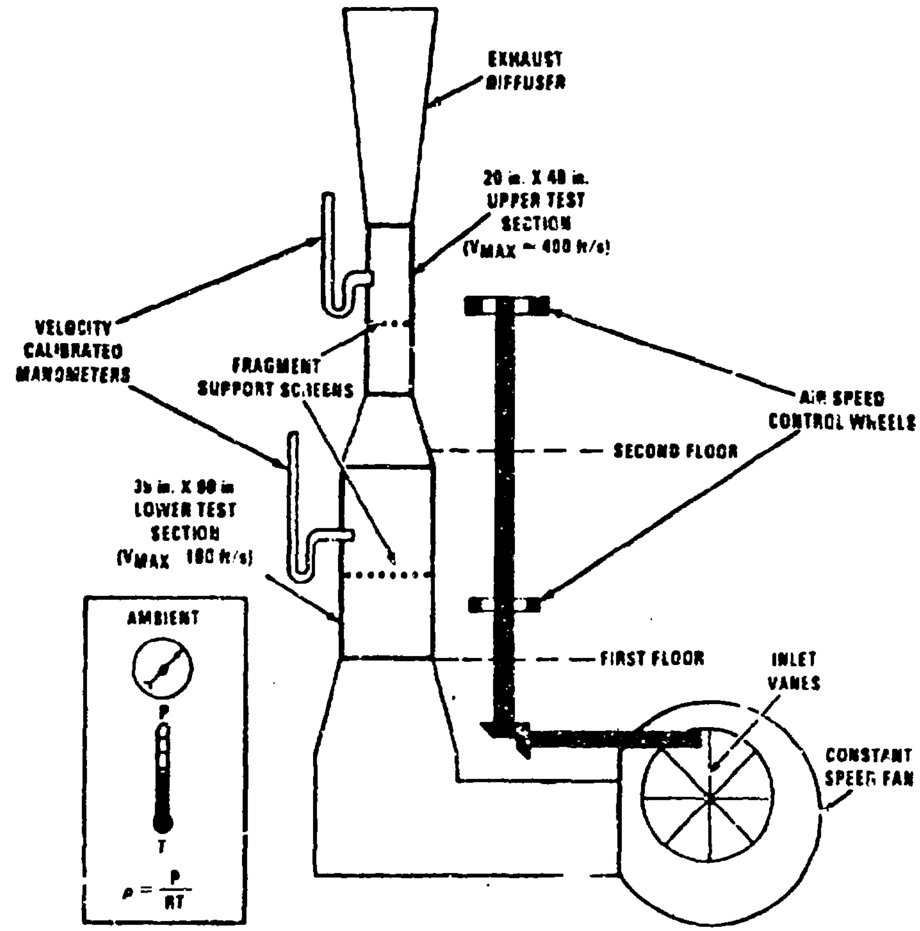
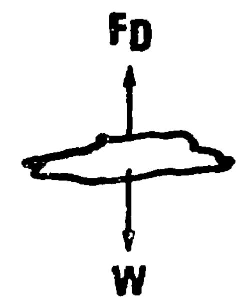


FIGURE 6

EXPERIMENTAL DRAG C



$$F_D = \text{DRAG FORCE} = \frac{C_D \rho A V^2}{2}$$

$$W = \text{FRAG WEIGHT}$$

$$F_D = W = \frac{C_D \rho A V^2}{2}$$

$$\boxed{C_D = \frac{2W}{\rho A V^2}}$$

FIGURE 7

DRAG COEFFICIENT SENSITIVITY

$F_0 = 20$ deg $A/M = 8$ in.^{2}/lb $V_0 = 5000$ ft/s

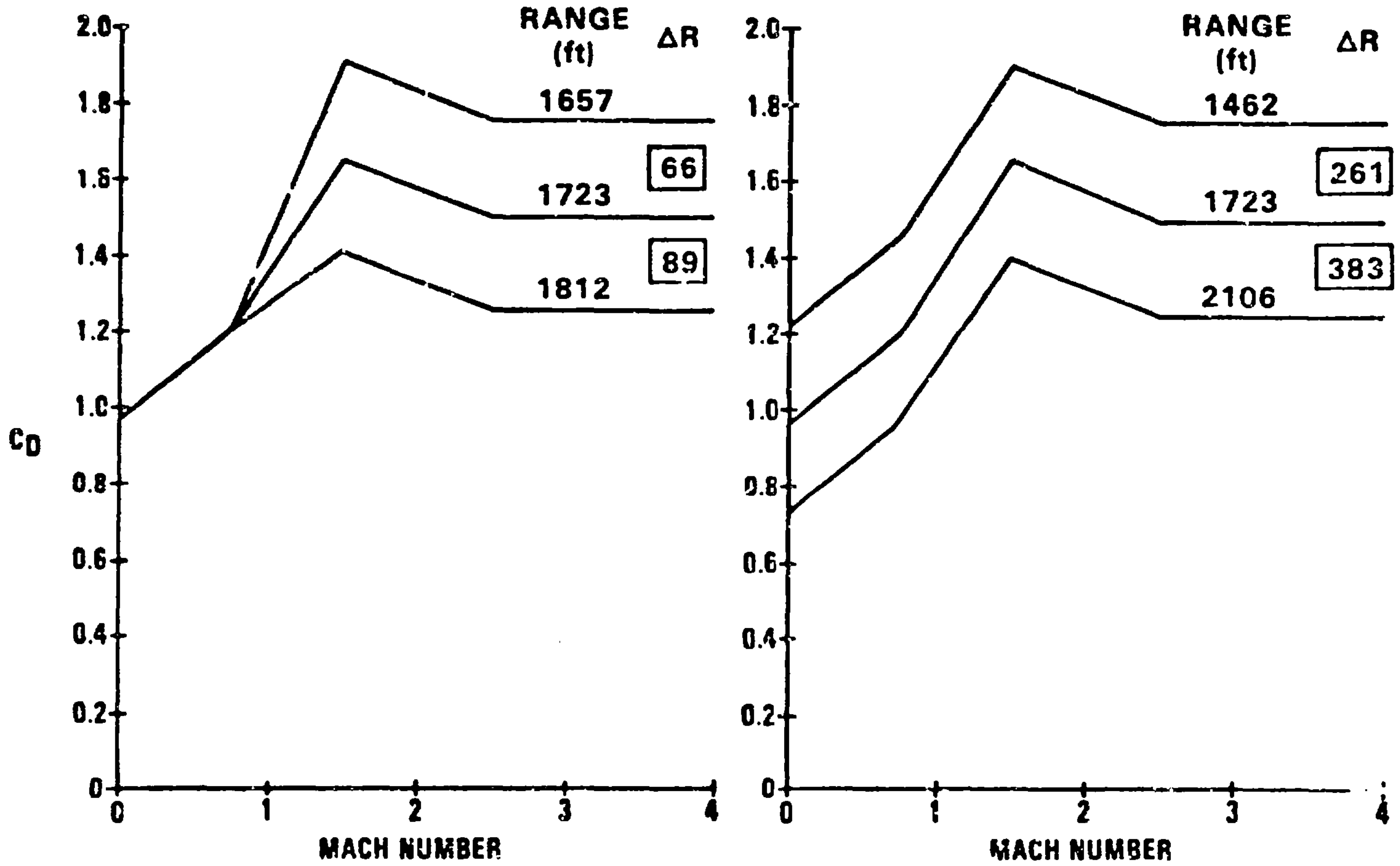


FIGURE 8

VELOCITY VERSUS RANGE RATIO

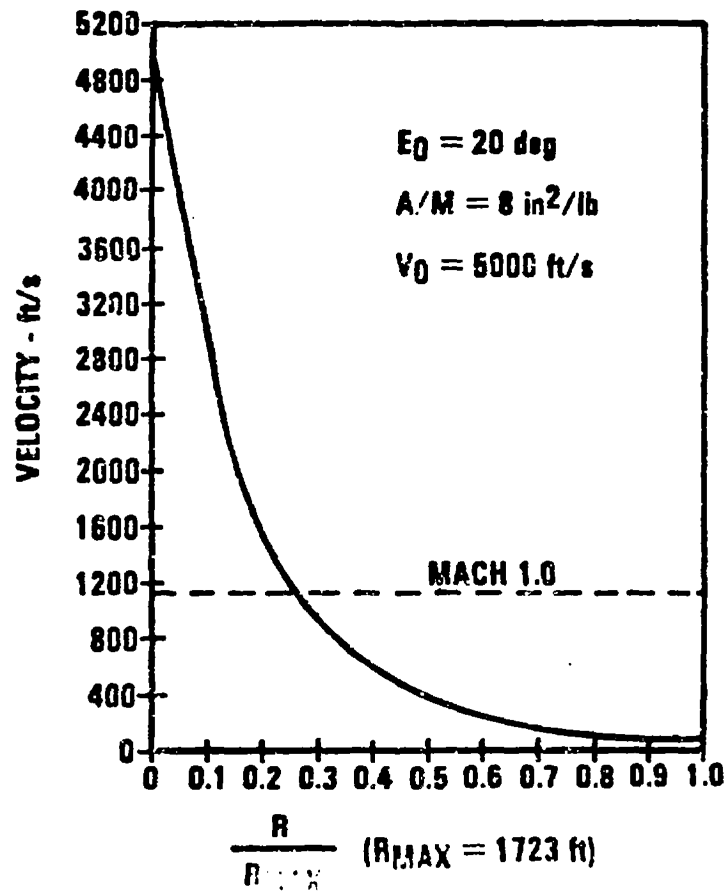


FIGURE 9

DRAG COEFFICIENT (C_D) vs. PRESENTED AREA RATIO (A_R)

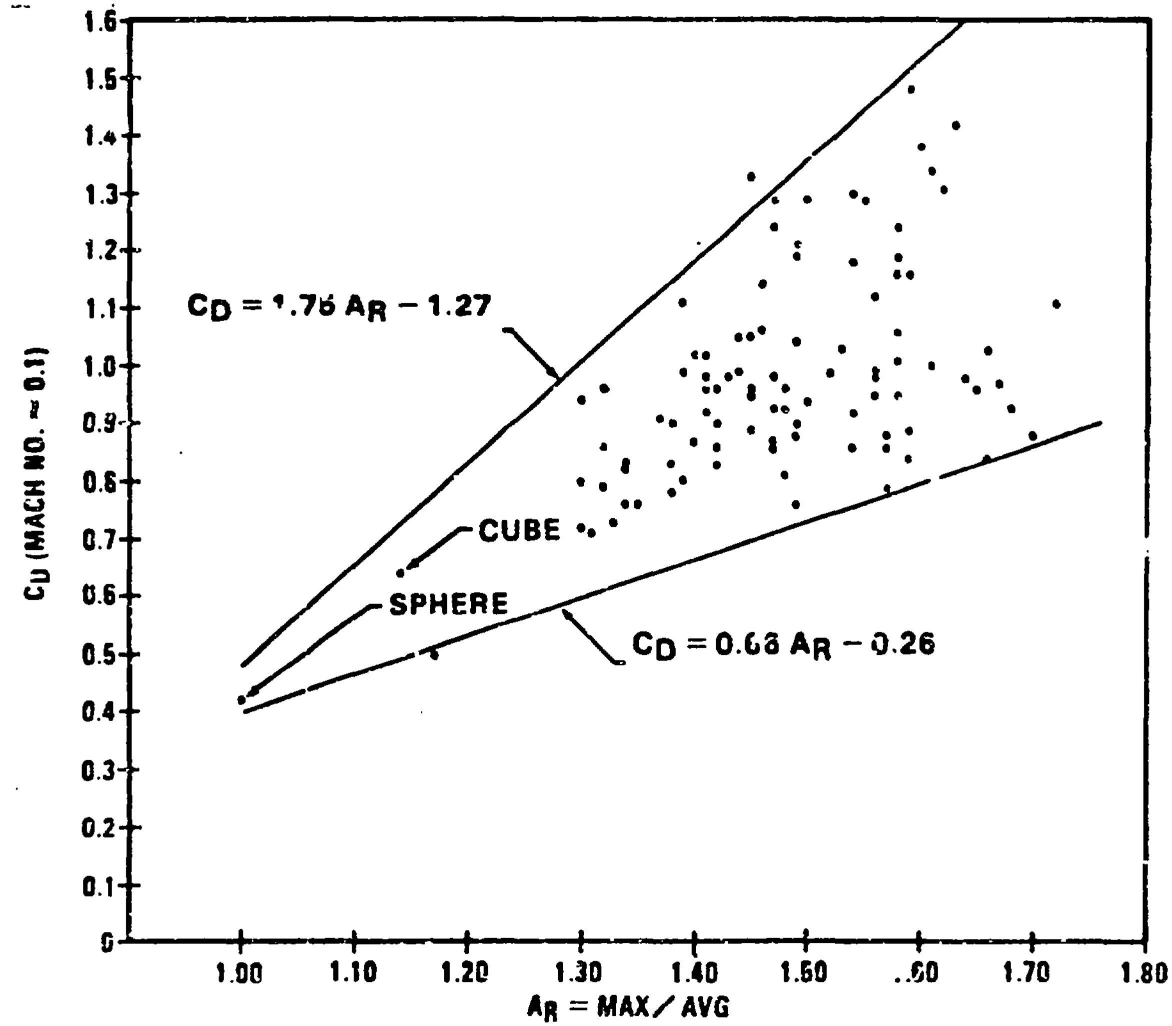


FIGURE 10

CD AND RANGE UNCERTAINTIES

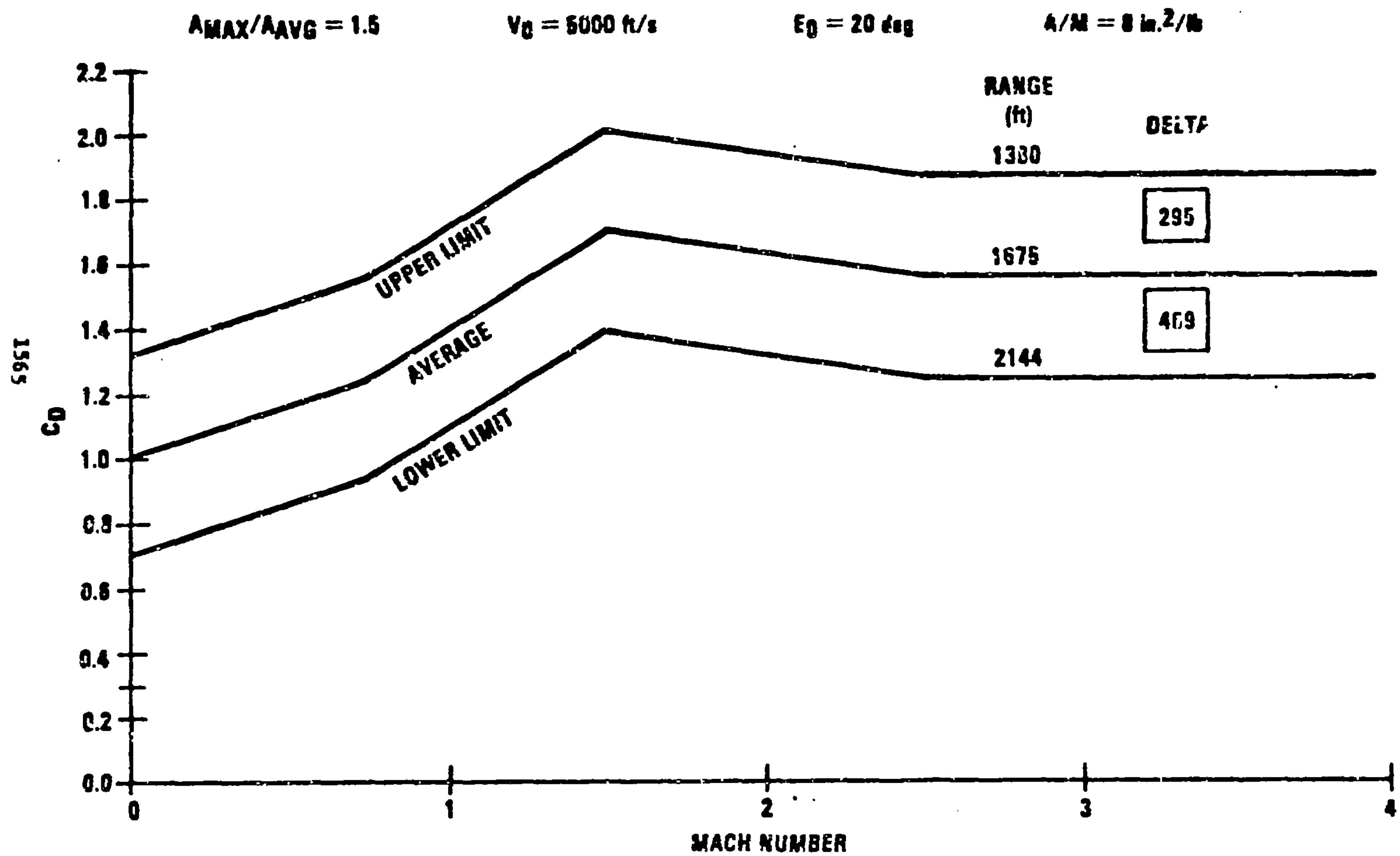


FIGURE 11

APPENDIX A

This Appendix contains 6 Tables and 9 Figures.

Table A-1 contains 16 presented areas measured by the icosahedron gage for the 84 fragments which could be mounted on the gage. Table A-2 presents the linear and perimeter measurements for all 96 fragments. LWP, LTP and TWP are the perimeter measurements in the LW, LT and TW planes, respectively. Table A-2 also contains the subsonic (M = 0.1) C_D measured for each fragment in the vertical wind tunnel. Table A-3 contains the presented area measurements for the 96 fragments obtained from the icosahedron gage and calculations using the equivalent rectangular parallelepipeds. Tables A-4, A-5 and A-6 contain the dimentionless ratios which were investigated as correlation parameters for C_D. Note that the fragments have been reordered in ascending C_D to help in the C_D correlation. The old frag number is that designated in Tables A-1, A-2 and A-3.

During the wind tunnel testing, the motion of each fragment was recorded. It was found that the motions could be defined in 9 distinct types. Each figure shows the plan views (L-W plane) of those fragments exhibiting the distinct motion indicated on the figure. Two numbers are given below each fragment. The first is the fragment number contained in Tables A-1, A-2 and A-3. The second number, in parenthesis, is the subsonic C_D measured in the vertical wind tunnel. It was hoped that knowing the shape, motion and C_D might provide an additional method for correlation. Currently, this has not been realized. It is interesting to note that only 35 percent of the fragments tumble randomly. This is at odds with the traditional assumption that all fragments tumble randomly in flight. It is because of the traditional assumption that C_D is calculated using the average presented area.

TABLE A1
PRESENTED AREA (SQ. IN.)
(ICOSAHEDRON GAGE)

FRAG	PRESENTED AREA															
NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.198	0.210	0.274	0.284	0.311	0.323	0.323	0.326	0.348	0.357	0.387	0.397	0.406	0.406	0.409	0.433
2	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785
3	0.630	0.607	0.865	0.889	0.827	0.854	0.880	0.890	0.858	0.893	0.920	0.932	0.944	0.932	0.976	0.983
4	0.192	0.229	0.236	0.242	0.278	0.288	0.293	0.296	0.306	0.307	0.311	0.338	0.339	0.353	0.359	0.363
5	0.171	0.240	0.245	0.270	0.280	0.290	0.359	0.373	0.355	0.400	0.410	0.443	0.452	0.492	0.536	0.576
6	0.157	0.216	0.228	0.247	0.267	0.256	0.270	0.276	0.304	0.311	0.339	0.361	0.361	0.376	0.376	0.412
7	0.197	0.203	0.237	0.243	0.269	0.256	0.290	0.291	0.309	0.312	0.327	0.366	0.373	0.384	0.399	0.412
8	0.183	0.213	0.247	0.271	0.274	0.291	0.335	0.360	0.367	0.434	0.426	0.473	0.475	0.526	0.551	0.500
9	0.183	0.190	0.285	0.285	0.307	0.315	0.327	0.334	0.337	0.401	0.401	0.401	0.435	0.476	[illegible]	0.495
10	0.230	0.240	0.262	0.271	0.320	0.348	0.357	0.391	0.438	0.443	0.570	0.573	0.580	0.585	0.622	0.700
11	0.281	0.217	0.257	0.267	0.275	0.288	0.292	0.316	0.337	0.360	0.404	0.407	0.413	0.416	0.434	0.405
12	0.214	0.222	0.226	0.240	0.256	0.270	0.277	0.258	0.336	0.358	0.385	0.385	0.443	0.455	0.404	0.510
13	0.206	0.231	0.239	0.240	0.245	0.258	0.260	0.269	0.208	0.296	0.303	0.310	0.320	0.349	0.333	0.333
14	0.190	0.265	0.278	0.278	0.290	0.298	0.303	0.339	0.347	0.357	0.366	0.374	0.440	0.442	0.445	0.457
15	0.222	0.237	0.266	0.276	0.300	0.303	0.325	0.335	0.337	0.349	0.393	0.396	0.400	0.425	0.442	0.457
16	0.206	0.236	0.329	0.339	0.375	0.383	0.388	0.423	0.423	0.438	0.472	0.492	0.522	0.546	0.551	0.566
17	0.218	0.239	0.296	0.327	0.338	0.337	0.337	0.349	0.338	0.413	0.432	0.434	0.467	0.496	0.506	0.552
18	0.247	0.257	0.294	0.311	0.313	0.316	0.374	0.401	0.404	0.421	0.423	0.423	0.445	0.453	0.475	0.521
19	0.213	0.225	0.252	0.255	0.267	0.300	0.330	0.345	0.348	0.372	0.414	0.443	0.473	0.477	0.488	0.517
20	0.223	0.256	0.343	0.360	0.377	0.395	0.424	0.436	0.433	0.487	0.508	0.519	0.522	0.522	0.544	0.617
21	0.200	0.256	0.380	0.313	0.382	0.391	0.416	0.421	0.422	0.400	0.612	0.633	0.641	0.649	0.668	0.744
22	0.201	0.338	0.388	0.41[illegible]	0.418	0.434	0.508	0.538	0.577	0.622	0.632	0.641	0.676	0.791	0.784	0.806
23	0.272	0.338	0.341	0.373	0.380	0.412	0.437	0.451	0.468	0.471	0.490	0.508	0.510	0.591	0.596	0.613
24	0.265	0.275	0.275	0.290	0.295	0.400	0.400	0.441	0.444	0.464	0.593	0.603	0.618	0.630	0.640	0.745
25	0.260	0.262	0.487	0.409	0.429	0.431	0.458	0.505	0.500	0.519	0.612	0.637	0.670	0.781	0.784	0.794
26	0.294	0.335	0.387	0.441	0.455	0.470	0.495	0.509	0.538	0.618	0.615	0.615	0.634	0.720	0.749	0.764
27	0.339	0.333	0.424	0.446	0.473	0.506	0.515	0.522	0.538	0.547	0.571	0.640	0.642	0.696	0.740	0.745
28	0.335	0.364	0.421	0.445	0.475	0.477	0.480	0.536	0.536	0.550	0.553	0.614	0.644	0.666	0.697	0.751
29	0.351	0.361	0.398	0.417	0.437	0.488	0.523	0.536	0.542	0.559	0.562	0.572	0.606	0.638	0.678	0.692
30	0.295	0.325	0.340	0.429	0.432	0.454	0.503	0.538	0.537	0.554	0.579	0.581	0.606	0.633	0.649	0.735
31	0.344	0.379	0.393	0.400	0.411	0.418	0.423	0.448	0.477	0.494	0.528	0.531	0.536	0.536	0.540	0.578
32	0.289	0.487	0.501	0.531	0.536	0.546	0.558	0.638	0.658	0.675	0.695	0.695	0.738	0.760	0.792	0.812
33	0.368	0.385	0.409	0.439	0.439	0.458	0.458	0.471	0.478	0.478	0.580	0.810	0.547	0.576	0.594	0.596
34	0.313	0.491	0.495	0.526	0.536	0.565	0.565	0.587	0.594	0.609	0.611	0.697	0.722	0.744	0.832	0.842
35	0.312	0.322	0.418	0.489	[illegible]	0.592	0.600	0.627	0.716	0.763	0.823	0.854	0.889	0.894	0.907	1.047
36	0.361	0.391	0.353	0.454	0.510	0.543	0.502	0.592	0.599	0.631	0.677	0.687	0.738	0.795	0.856	0.906
37	0.380	0.432	0.444	0.447	0.523	0.572	0.599	0.599	0.621	0.643	0.667	0.709	0.743	0.740	0.812	0.853
38	0.369	0.349	0.371	0.425	0.459	0.501	0.501	0.500	0.508	0.594	0.633	0.633	0.678	0.692	0.721	0.787
39	0.418	0.467	0.477	0.494	0.536	0.587	0.665	0.683	0.734	0.800	0.822	0.864	0.906	0.937	0.962	1.045
40	0.277	0.525	0.544	0.544	0.569	0.571	0.571	0.659	0.609	0.691	0.694	0.694	0.708	0.745	0.758	0.787
41	0.404	0.498	0.501	0.531	0.543	0.548	0.533	0.575	0.508	[illegible]	0.572	0.631	0.635	0.635	0.663	0.698
42	0.422	0.472	0.495	0.581	0.618	0.639	0.654	0.559	0.578	0.639	0.689	0.708	0.758	0.763	0.772	0.876
43	0.553	0.731	0.760	0.780	0.800	0.928	0.977	1.007	1.056	1.096	1.125	1.125	1.194	1.283	1.312	1.431
44	0.381	0.440	0.506	0.516	0.540	0.546	0.543	0.550	0.578	0.572	0.577	0.594	0.599	0.604	0.624	0.600
45	0.406	0.429	0.481	0.480	0.522	0.535	0.576	0.591	0.591	0.610	0.635	0.635	0.687	0.706	0.721	0.780
46	0.406	0.452	0.469	0.492	0.543	0.543	0.585	0.651	0.678	0.680	0.722	0.724	0.807	0.818	0.820	0.823
47	0.467	0.472	0.536	0.543	0.553	0.580	0.604	0.617	0.622	0.634	0.675	0.715	0.739	0.739	0.795	0.820
48	0.390	0.425	0.477	0.489	0.516	0.531	0.594	0.653	0.712	0.722	0.802	0.832	0.893	0.905	0.917	0.974
49	0.370	0.438	0.472	0.509	0.512	0.340	0.531	0.598	0.646	0.659	0.759	0.776	0.781	0.784	0.864	0.896
50	0.427	0.440	0.518	0.537	0.581	0.589	0.591	0.594	0.633	0.653	0.704	0.713	0.763	0.797	0.798	0.831

TABLE A1 (CONTINUED)
PRESENTED AREA (SQ. IN.)
(ICOSAHEDRON GAGE)

PRESENTED AREA

NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
51	0.482	0.427	0.568	0.609	0.737	0.757	0.787	0.821	0.855	0.885	0.898	0.893	0.920	0.925	0.980	1.053
52	0.400	0.452	0.492	0.526	0.570	0.625	0.625	0.625	0.832	0.866	0.876	0.876	1.030	1.070	1.172	1.202
53	0.543	0.540	0.567	0.715	0.725	0.725	0.730	0.760	0.779	0.784	0.804	0.814	0.839	0.839	0.800	0.870
54	0.530	0.501	0.535	0.619	0.634	0.663	0.747	0.821	0.994	1.033	1.231	1.240	1.364	1.443	1.526	1.670
55	0.435	0.476	0.633	0.673	0.650	0.742	0.785	0.821	0.831	0.964	0.989	1.018	1.053	1.067	1.132	1.200
56	0.358	0.644	0.684	0.713	0.773	0.882	0.852	0.921	0.956	1.059	1.069	1.079	1.148	1.246	1.256	1.385
57	0.430	0.450	0.562	0.605	0.646	0.670	0.749	0.754	0.775	0.784	0.810	0.828	0.828	0.863	0.851	0.961
58	0.283	0.619	0.619	0.713	0.723	0.738	0.777	0.910	0.910	0.915	1.004	1.064	1.078	1.132	1.201	1.344
59	0.452	0.516	0.536	0.568	0.625	0.720	0.827	0.856	0.865	0.876	1.212	1.266	1.201	1.395	1.318	1.552
60	0.485	0.506	0.530	0.614	0.674	0.680	0.693	0.723	0.740	0.767	0.772	0.802	0.822	0.915	0.925	0.965
61	0.525	0.525	0.584	0.732	0.742	0.821	0.940	0.949	1.048	1.048	1.305	1.305	1.394	1.453	1.453	1.560
62	0.639	0.660	0.732	0.841	0.856	0.861	0.870	0.885	0.905	0.905	0.905	0.905	0.915	0.935	0.935	0.994
63	0.390	0.447	0.713	0.718	0.733	0.802	0.837	0.856	0.945	0.965	1.024	1.060	1.246	1.325	1.330	1.396
64	0.517	0.630	0.635	0.660	0.773	0.783	0.882	0.900	1.157	1.237	1.434	1.333	1.617	1.720	1.804	1.942
65	0.435	0.480	0.618	0.624	0.677	0.697	0.727	0.766	0.786	0.860	0.904	0.930	0.980	1.000	1.027	1.131
66	0.531	0.500	0.555	0.598	0.624	0.733	0.762	0.772	0.782	0.792	1.063	1.080	1.090	1.113	1.117	1.330
67	0.622	0.637	0.735	0.760	0.800	0.834	0.839	0.869	0.890	0.962	1.100	1.200	1.214	1.240	1.250	1.451
68	0.385	0.600	0.615	0.626	0.693	0.733	0.807	0.876	0.896	0.925	0.930	1.004	1.000	1.000	1.113	1.137
69	0.565	0.565	0.737	0.737	0.757	0.836	0.871	0.890	0.979	1.004	1.043	1.003	1.167	1.127	1.147	1.200
70	0.424	0.572	0.607	0.661	0.700	0.700	0.725	0.775	0.780	0.785	0.814	0.853	0.873	0.880	0.905	0.912
71	0.586	0.546	0.792	0.882	0.882	0.970	0.990	1.079	1.079	1.315	1.365	1.454	1.464	1.700	1.700	1.870
72	0.514	0.663	0.670	0.712	0.934	0.990	1.013	1.007	1.330	1.363	1.555	1.605	1.750	1.022	1.950	2.093
73	0.525	0.671	0.700	0.710	0.720	0.823	0.922	1.006	1.031	1.000	1.341	1.351	1.430	1.450	1.450	1.692
74	0.635	0.670	0.700	0.759	0.912	0.912	0.951	0.976	1.030	1.035	1.056	1.100	1.237	1.272	1.356	1.430
75	0.500	0.602	0.854	0.850	0.873	0.893	1.036	1.051	1.130	1.160	1.327	1.376	1.391	1.411	1.411	1.640
76	0.467	0.660	0.740	0.730	0.790	0.902	0.891	1.044	1.217	1.232	1.241	1.400	1.577	1.600	1.725	2.000
77	0.482	0.571	0.837	0.916	1.005	1.025	1.035	1.064	1.133	1.262	1.281	1.311	1.530	1.606	1.745	1.755
78	0.835	0.940	0.977	1.007	1.056	1.155	1.224	1.234	1.303	1.333	1.412	1.500	1.550	1.569	1.747	1.856
79	0.682	0.761	0.900	0.900	0.900	1.117	1.166	1.186	1.196	1.294	1.600	1.630	1.719	1.760	1.700	2.076
80	0.674	0.694	0.961	0.971	1.115	1.130	1.207	1.227	1.257	1.360	1.415	1.464	1.494	1.523	1.563	1.700
81	0.602	0.830	1.045	1.075	1.105	1.125	1.125	1.154	1.174	1.203	1.322	1.342	1.371	1.500	1.540	1.600
82	0.685	0.763	0.813	0.842	0.872	0.897	0.986	1.006	1.000	1.160	1.183	1.201	1.296	1.400	1.563	1.553
83	0.640	0.618	0.776	0.850	0.800	0.900	1.023	1.314	1.343	1.397	1.447	1.626	1.600	1.876	1.903	1.975
84	0.685	0.871	0.890	1.050	1.060	1.157	1.196	1.196	1.374	1.512	1.710	1.729	1.820	1.937	2.005	2.205

TABLE A2
FRAGMENT DATA

FRAG NO.	SOURCE	WEIGHT GRAINS	LMAX IN.	WMAX IN.	TMAX IN.	LAVG IN.	WAVG IN.	TAVG IN.	LWP IN.	LTP IN.	TWP IN.	CD
1	1	133.3	1.29	0.29	0.25	1.3	0.3	0.25	3.23	3.19	1.13	0.94
2	2	1030.4	SPHERE		DIAMETER = 1.00 IN.				ALL PERIMETERS = 3.14 IN.			CD = .42
3	3	835.0	0.76	0.76	0.76	0.8	0.8	0.76	3.06	3.06	3.06	0.64
4	5	108.7	0.93	0.60	0.49	0.9	0.5	0.13	2.38	2.19	1.75	0.91
5	5	112.3	1.73	0.40	0.21	1.6	0.4	0.09	3.63	3.50	1.25	1.19
6	5	113.2	1.02	0.68	0.25	1.0	0.5	0.12	2.56	2.13	1.50	1.06
7	5	113.2	1.08	0.60	0.27	1.0	0.5	0.12	2.69	2.25	1.50	1.05
8	5	119.7	1.23	0.81	0.21	1.2	0.6	0.08	3.25	2.75	1.75	1.34
9	5	121.5	1.24	0.58	0.29	1.1	0.5	0.11	3.06	2.69	1.50	0.93
10	5	121.8	1.40	0.72	0.22	1.2	0.7	0.07	3.44	2.38	1.50	0.97
11	5	128.6	1.04	0.71	0.27	1.1	0.5	0.12	2.81	2.31	1.50	0.76
12	5	128.8	0.94	0.79	0.28	0.8	0.8	0.10	2.75	2.00	1.75	0.80
13	5	130.0	0.83	0.80	0.44	0.7	0.6	0.16	2.31	2.00	1.94	0.83
14	5	132.9	1.00	0.75	0.33	1.0	0.5	0.14	2.00	2.31	1.94	0.96
15	5	135.5	1.02	0.76	0.32	0.9	0.6	0.13	2.75	2.38	1.69	0.98
16	5	150.1	1.74	0.55	0.20	1.7	0.4	0.11	3.69	3.50	1.50	0.93
17	5	155.5	1.28	0.63	0.32	1.3	0.5	0.12	3.00	2.63	1.50	0.94
18	5	158.6	1.35	0.71	0.34	1.4	0.4	0.14	3.06	2.75	1.81	0.83
19	5	161.1	0.98	0.74	0.25	1.0	0.6	0.14	2.81	2.13	1.69	1.21
20	5	178.2	1.43	0.82	0.37	1.3	0.6	0.12	3.38	2.81	1.81	1.29
21	5	188.5	1.70	0.76	0.27	1.5	0.6	0.11	3.75	3.38	1.63	1.38
22	5	205.7	1.84	0.65	0.38	1.5	0.6	0.12	4.00	4.06	1.44	1.18
23	5	213.0	1.33	0.73	0.38	1.1	0.6	0.17	3.13	2.75	1.88	1.02
24	5	214.6	1.07	0.90	0.26	1.0	0.8	0.14	3.19	2.38	1.94	1.48
25	5	235.4	1.51	0.81	0.29	1.5	0.6	0.13	3.56	2.88	1.94	1.38
26	5	239.4	1.40	0.79	0.41	1.5	0.6	0.14	3.00	3.06	1.75	1.19
27	5	241.6	1.54	0.83	0.43	1.4	0.6	0.15	3.81	3.44	1.63	0.89
28	5	244.0	1.38	0.78	0.40	1.3	0.6	0.16	3.50	3.31	2.06	1.33
29	6	248.7	1.38	0.74	0.38	1.3	0.6	0.16	3.19	3.06	1.63	0.96
30	5	255.1	1.74	0.77	0.35	1.7	0.5	0.13	3.94	3.63	1.75	1.34
31	5	260.9	1.06	0.88	0.47	1.1	0.6	0.21	2.69	2.44	2.06	0.96
32	5	277.4	1.87	0.77	0.46	1.9	0.5	0.15	4.06	3.54	1.94	0.90
33	6	288.2	1.20	1.09	0.45	1.1	0.6	0.22	2.00	2.44	2.13	0.86
34	6	291.1	1.40	0.89	0.44	1.4	0.7	0.13	3.94	3.31	2.06	1.29
35	4	302.9	1.91	0.60	0.32	1.9	0.6	0.14	4.38	4.00	1.81	0.73
36	4	304.0	1.08	0.80	0.36	1.5	0.7	0.13	3.75	3.44	1.75	1.15
37	6	308.4	1.50	0.82	0.37	1.4	0.7	0.16	3.75	3.31	1.88	0.96
38	4	313.1	1.54	0.86	0.38	1.3	0.7	0.18	3.44	3.19	1.81	0.90
39	4	323.9	1.42	1.13	0.35	1.3	0.9	0.14	4.56	2.81	2.69	0.86
40	5	325.7	1.56	0.78	0.57	1.4	0.6	0.20	3.44	3.44	1.81	0.82
41	4	333.2	1.12	1.09	0.60	1.1	0.8	0.19	2.06	2.75	2.69	0.76
42	6	335.0	1.73	0.65	0.33	1.5	0.6	0.19	4.25	3.94	1.75	0.90
43	4	352.8	2.71	0.84	0.19	2.6	0.7	0.10	7.25	6.25	1.94	0.93
44	4	354.6	1.17	0.82	0.74	1.1	0.7	0.23	3.31	3.06	2.25	0.72
45	4	354.9	1.34	0.95	0.38	1.2	0.7	0.22	3.38	3.06	2.25	0.80
46	5	357.9	1.35	1.14	0.51	1.3	0.7	0.20	3.81	3.06	2.25	0.83
47	6	358.2	1.45	0.82	0.53	1.4	0.7	0.19	3.08	3.13	2.31	0.87
48	5	360.2	1.38	1.23	0.46	1.2	0.9	0.1	4.00	2.88	2.81	1.04
49	5	370.3	1.38	0.83	0.43	1.3	0.8	0.18	3.00	2.88	2.06	1.14
50	4	366.0	1.12	0.99	0.62	1.2	0.8	0.20	3.69	2.94	2.56	1.11

TABLE A2 CONTINUED
FRAGMENT DATA

FRAG NO.	SOURCE	WEIGHT GRAINS	LMAX IN.	WMAX IN.	TMAX IN.	LAVG IN.	WAVG IN.	TAVG IN.	LWP IN.	LTP IN.	TWP IN.	CD
51	4	390.2	2.25	0.64	0.51	2.0	0.6	0.17	4.80	4.75	1.69	1.05
52	6	393.3	1.66	1.07	0.40	1.6	0.9	0.16	4.44	3.31	2.31	1.16
53	4	395.1	1.62	0.75	0.52	1.5	0.7	0.19	4.56	4.06	2.13	0.76
54	4	404.6	2.09	1.16	0.27	2.0	0.9	0.11	5.25	4.31	2.50	1.11
55	5	432.7	2.03	0.75	0.42	1.9	0.7	0.17	4.88	4.50	1.69	0.88
56	4	455.9	2.75	0.76	0.37	2.3	0.6	0.16	5.00	5.69	1.81	1.03
57	6	461.7	1.56	0.96	0.47	1.3	0.8	0.25	3.63	3.30	2.13	0.70
58	6	464.0	2.05	0.98	0.52	2.1	0.7	0.16	4.81	4.25	2.25	1.12
59	4	483.2	1.50	1.36	0.33	1.6	1.0	0.15	4.02	3.13	2.94	1.03
60	6	484.1	1.54	0.93	0.61	1.3	0.8	0.24	3.63	3.44	2.30	0.90
61	4	486.7	2.47	1.05	0.37	2.1	0.9	0.13	5.69	3.06	2.31	0.96
62	4	488.3	1.83	0.90	0.59	1.0	0.7	0.20	5.56	4.46	2.81	0.73
63	6	490.9	2.13	1.02	0.39	2.1	0.8	0.15	5.13	4.69	2.00	0.86
64	4	495.1	1.96	1.59	0.50	2.0	1.0	0.15	6.30	3.81	3.25	0.80
65	5	505.0	1.72	0.91	0.41	1.8	0.6	0.24	4.44	3.75	1.94	0.85
66	6	519.6	1.62	1.20	0.39	1.4	1.0	0.19	4.50	3.06	2.81	1.06
67	6	531.9	2.12	1.06	0.40	2.0	0.8	0.17	5.56	4.31	2.38	0.92
68	5	547.9	1.60	1.00	0.42	1.6	0.8	0.22	3.63	3.50	3.44	0.92
69	6	556.2	1.57	1.07	0.42	1.9	0.8	0.19	5.06	4.44	2.25	0.97
70	4	561.2	1.73	0.60	0.67	1.5	0.7	0.27	4.19	4.13	2.06	0.71
71	4	600.4	2.57	0.95	0.35	2.3	0.9	0.15	6.06	5.25	2.13	0.98
72	6	651.7	2.19	1.30	0.30	2.1	1.1	0.14	5.63	4.31	2.75	0.93
73	6	655.4	1.58	1.37	0.44	1.6	1.1	0.19	4.94	3.63	2.94	0.84
74	4	656.0	1.83	1.16	0.66	1.9	0.8	0.22	4.63	4.00	3.00	0.86
75	6	660.5	2.31	1.07	0.64	2.1	0.8	0.20	5.56	5.06	2.69	0.95
76	5	713.9	2.12	1.24	0.50	1.8	1.0	0.20	5.06	4.31	3.00	0.84
77	6	719.1	2.61	0.53	0.38	2.6	0.8	0.10	6.00	5.06	2.19	1.29
78	4	767.0	2.05	1.16	0.53	2.8	0.7	0.20	7.44	6.13	2.80	0.90
79	6	776.7	2.52	1.27	0.45	2.3	1.0	0.17	7.13	5.86	2.65	1.31
80	4	777.0	2.85	0.86	0.50	2.8	0.7	0.20	6.63	6.06	2.19	0.96
81	6	782.2	2.43	0.97	0.43	2.4	0.8	0.21	5.63	5.63	2.13	0.98
82	4	804.0	1.68	1.49	0.50	1.6	1.1	0.23	4.00	3.56	3.44	0.81
83	6	833.7	1.76	1.59	0.40	1.6	1.4	0.19	5.69	3.69	3.50	0.89
84	6	865.3	2.98	1.07	0.43	3.0	0.9	0.16	7.00	5.81	2.31	1.00
85	4	1617.7	3.23	1.27	0.56	2.7	1.1	0.20	7.81	6.75	2.81	0.53
86	6	1658.0	3.37	1.95	0.45	3.3	1.2	0.21	8.81	6.75	4.19	1.24
87	4	1798.4	3.53	2.05	0.66	3.3	1.2	0.23	8.50	6.56	3.69	0.98
88	6	1973.2	3.92	1.96	0.45	3.0	1.2	0.22	9.31	8.00	3.81	0.95
89	4	2005.7	2.50	1.49	0.97	2.5	0.9	0.45	5.75	5.69	3.80	0.80
90	6	2006.2	2.71	2.00	0.73	2.4	1.0	0.43	6.19	5.81	3.56	0.79
91	6	2033.6	3.38	1.84	0.46	3.0	1.4	0.25	8.00	6.25	3.88	0.99
92	4	2763.3	4.50	2.69	0.57	4.3	1.5	0.22	12.25	8.80	5.56	1.42
93	6	3140.0	4.55	1.98	0.46	4.1	1.5	0.26	13.06	10.00	3.31	1.01
94	4	3270.2	3.17	1.89	0.74	2.9	1.4	0.41	8.56	6.81	4.59	1.02
95	7	15550.1	3.17	2.81	2.33	3.1	2.0	1.20	9.63	8.80	8.19	0.56
96	7	23413.5	4.50	3.77	1.79	4.2	3.6	0.84	13.63	9.81	8.63	0.99

SOURCE CODE

1 – BAR (1/4 X 1/4 X 1 1/4)
2 – 1.00 IN. DIAMETER SPHERE
3 – .75 IN. PER SIDE CUBE
4 – 155MM M107 PROJECTILE
5 – 76MM MK 165 PROJECTILE
6 – MK 84 LOW DRAG BOMB
7 – MK 82 LOW DRAG BOMB

TABLE A3

ICOSAHEDRON V3 CALCULATED AREAS

FRAG	MIN AREA		MAX AREA		AVG AREA		STD DEV		VARIANCE	
NO.	ICOS	CALC	ICOS	CALC	ICOS	CALC	ICOS	CALC	ICOS	CALC
1	0.26	0.07	0.43	0.5[illegible]	0.34	0.38	0.07	0.09	0.005	0.008
2	0.79	0.79	0.79	0.79	0.78	0.79	0.00	0.00	0.000	0.003
3	0.64	0.58	0.98	1.00	0.87	0.87	0.10	0.09	0.009	0.008
4	0.19	0.06	0.37	0.47	0.30	0.31	0.05	0.11	0.003	0.012
5	0.17	0.04	0.58	0.66	0.37	0.41	0.11	0.16	0.013	0.027
6	0.16	0.06	0.41	0.52	0.30	0.34	0.07	0.12	0.005	0.015
7	0.20	0.06	0.41	0.52	0.30	0.34	0.07	0.12	0.005	0.015
8	0.18	0.05	0.58	0.73	0.37	0.44	0.12	0.19	0.015	0.036
9	0.18	0.06	0.50	0.57	0.35	0.37	0.09	0.14	0.009	0.019
10	0.23	0.05	0.70	0.85	0.43	0.49	0.15	0.22	0.023	0.050
11	0.20	0.06	0.49	0.57	.34	0.37	0.08	0.14	0.007	0.018
12	0.21	0.08	0.51	0.65	.33	0.40	0.10	0.16	0.010	0.027
13	0.21	0.10	0.36	0.44	.28	0.31	0.05	0.10	0.002	0.009
14	0.19	0.07	0.46	0.52	0.34	0.35	0.07	0.12	0.005	0.014
15	0.22	0.08	0.46	0.56	0.34	0.37	0.07	0.13	0.005	0.017
16	0.21	0.05	0.57	0.71	0.42	0.46	0.11	0.17	0.011	0.029
17	0.21	0.06	0.55	0.67	0.38	0.43	0.10	0.16	0.009	0.026
18	0.25	0.06	0.52	0.60	0.[illegible]	0.41	0.08	0.13	0.007	0.018
19	0.21	0.08	0.52	0.62	0.[illegible]	0.41	0.10	0.15	0.010	0.021
20	0.22	0.07	0.62	0.80	0.[illegible]	0.50	0.10	0.20	0.010	0.039
21	0.20	0.06	0.74	0.92	0.[illegible]3	0.56	0.16	0.23	0.026	0.054
22	0.28	0.07	0.60	0.92	0.55	0.57	0.16	0.23	0.025	0.053
23	0.27	0.10	0.61	0.69	0.45	0.47	0.10	0.16	0.010	0.024
24	0.27	0.11	0.75	0.82	0.46	0.52	0.16	0.20	0.025	0.040
25	0.26	0.08	0.79	0.93	0.53	0.59	0.17	0.23	0.029	0.051
26	0.29	0.08	0.76	0.93	0.54	0.59	0.14	0.23	0.020	0.051
27	0.34	0.09	0.75	0.87	0.54	0.57	0.12	0.21	0.015	0.043
28	0.33	0.10	0.75	0.81	0.54	0.54	0.12	0.19	0.014	0.036
29	0.35	0.10	0.69	0.81	0.52	0.54	0.11	0.19	0.011	0.035
30	0.30	0.08	0.74	0.89	0.51	0.59	0.12	0.21	0.016	0.043
31	0.34	0.12	0.57	0.71	0.48	0.51	0.07	0.15	0.005	0.022
32	0.29	0.07	0.81	0.99	0.62	0.65	0.14	0.23	0.019	0.055
33	0.36	0.13	0.68	0.71	0.48	0.51	0.07	0.15	0.005	0.022
34	0.31	0.11	0.84	1.01	0.61	0.65	0.14	0.24	0.018	0.059
35	0.31	0.03	1.05	1.17	0.68	0.74	0.23	0.29	0.053	0.084
36	0.36	0.10	0.99	1.08	0.62	0.69	0.18	0.26	0.031	0.069
37	0.30	0.11	0.85	1.01	0.61	0.66	0.15	0.24	0.023	0.058
38	0.35	0.12	0.79	0.95	0.55	0.63	0.14	0.22	0.019	0.048
39	0.42	0.13	1.05	1.19	0.71	0.74	0.20	0.30	0.040	0.089
40	0.28	0.12	0.77	0.89	0.62	0.62	0.12	0.20	0.015	0.039
41	0.40	0.15	0.70	0.92	0.58	0.62	0.06	0.21	0.004	0.043
42	0.42	0.11	0.88	0.95	0.65	.65	0.12	0.21	0.015	0.046
43	0.55	0.07	1.43	1.84	1.02	.07	0.24	0.49	0.056	0.236
44	0.39	0.16	0.66	0.83	0.55	.60	0.07	0.17	0.004	0.029
45	0.41	0.15	0.79	0.89	0.39	.62	0.11	0.19	0.012	0.037
46	0.41	0.14	0.83	0.96	0.64	.66	0.14	0.21	0.020	0.046
47	0.47	0.13	0.82	1.02	0.63	.69	0.11	0.24	0.012	0.055
48	0.40	0.15	0.97	1.11	0.68	72	0.19	0.27	0.037	0.071
49	0.37	0.15	0.90	1.08	0.64	.71	0.16	0.25	0.025	0.064
50	0.43	0.16	0.83	1.00	0.64	.60	0.12	0.23	0.015	0.052

TABLE A3 (CONTINUED)
ICOSAHEDROM VS CALCULATED AREAS

FRAG	MIN AREA		MAX AREA		AVG AREA		STD DEV		VARIANCE	
NO.	ICOS	CALC	ICOS	CALC	ICOS	CALC	ICOS	CALC	ICOS	CALC
51	0.40	0.10	1.05	1.25	0.78	0.82	0.19	0.30	0.037	0.088
52	0.41	0.13	1.20	1.31	0.77	0.83	0.26	0.32	0.068	0.104
53	0.54	0.13	0.90	1.10	0.75	0.74	0.11	0.25	0.012	0.064
54	0.34	0.10	1.67	1.82	0.96	1.07	0.41	0.48	0.169	0.228
55	0.46	0.12	1.20	1.37	0.85	0.88	0.23	0.33	0.051	0.111
56	0.36	0.09	1.39	1.55	0.93	0.95	0.27	0.38	0.072	0.144
57	0.46	0.18	0.96	1.10	0.73	0.76	0.15	0.24	0.022	0.059
58	0.29	0.11	1.34	1.51	0.87	0.95	0.26	0.37	0.069	0.138
59	0.45	0.15	1.55	1.63	0.92	1.00	0.35	0.41	0.121	0.169
60	0.49	0.19	0.97	1.10	0.73	0.77	0.14	0.24	0.020	0.057
61	0.53	0.12	1.66	1.91	1.03	1.14	0.36	0.50	0.131	0.246
62	0.64	0.14	0.99	1.32	0.86	0.88	0.10	0.31	0.010	0.094
63	0.40	0.12	1.39	1.71	0.93	1.06	0.30	0.43	0.089	0.187
64	0.52	0.13	1.94	2.02	1.15	1.19	0.47	0.53	0.225	[illegible]
65	0.46	0.14	1.13	1.17	0.79	0.83	0.20	0.25	0.040	0.063
66	0.53	0.19	1.36	1.44	0.85	0.93	0.26	0.35	0.067	0.120
67	0.62	0.14	1.45	1.64	0.97	1.04	0.25	0.40	0.064	0.164
68	0.59	0.17	1.14	1.34	0.86	0.90	0.20	0.31	0.039	0.094
69	0.37	0.15	1.28	1.57	0.92	1.01	0.21	0.38	0.044	0.143
70	0.43	0.19	0.91	1.14	0.75	0.82	0.13	0.24	0.018	0.055
71	0.51	0.13	1.88	2.10	1.15	1.27	0.42	0.54	0.174	0.290
72	0.61	0.16	2.09	2.34	1.26	1.39	0.49	0.61	0.242	0.370
73	0.52	0.21	1.69	1.80	1.06	1.14	0.36	0.44	0.127	0.196
74	0.64	0.18	1.44	1.59	1.01	1.06	0.24	0.37	0.059	0.136
75	0.51	0.16	1.65	1.74	1.10	1.15	0.31	0.42	0.097	0.173
76	0.47	0.20	2.00	1.85	1.14	1.18	0.44	0.45	0.196	0.202
77	0.48	0.14	1.76	2.13	1.17	1.34	0.38	0.53	0.147	0.281
78	0.84	0.14	1.86	2.04	1.29	1.33	0.30	0.49	0.088	0.238
79	0.68	0.17	2.07	2.34	1.30	1.43	0.42	0.59	0.175	0.352
80	0.67	0.14	1.70	2.05	1.24	1.33	0.30	0.49	0.090	0.238
81	0.60	0.17	1.61	1.99	1.20	1.29	0.26	0.48	0.067	0.227
82	0.69	0.26	1.55	1.82	1.08	1.19	0.28	0.43	0.078	0.184
83	0.61	0.27	1.98	2.28	1.27	1.40	0.46	0.57	0.216	0.329
84	0.60	0.15	2.20	2.75	1.41	1.67	0.46	0.70	0.210	0.494
85		0.31		3.98		2.01		0.73		0.535
86		0.26		4.83		2.46		1.03		1.053
87		0.28		4.04		2.50		1.02		1.034
88		0.26		4.64		2.83		1.18		1.400
89		0.41		2.55		1.50		0.50		0.245
90		0.43		2.64		1.93		0.54		0.286
91		0.35		4.20		2.64		1.08		1.161
92		0.33		6.53		3.86		1.71		2.908
93		0.39		6.25		3.81		1.60		2.549
94		0.58		4.27		2.92		0.96		0.925
95		2.57		7.80		6.37		1.11		1.232
96		2.84		14.98		8.32		3.33		11.078

EXPLANATION OF COLUMN HEADINGS
MIN AREA - MINIMUM PRESENTED AREA (SQ. IN.)
MAX AREA - MAXIMUM PRESENTED AREA (SQ. IN.)
AVG AREA - AVERAGE PRESENTED AREA (SQ. IN.)
STD DEV - STANDARD DEVIATION OF PRESENTED AREA (SQ. IN.)
VARIANCE - VARIANCE OF PRESENTED AREA (IN. 4TH)
ICOS - AREAS CALCULATED FROM ICOSAHEDRON GAGE DATA
CALC - AREAS CALCULATED FROM APPROXIMATING RECTANGULAR PARALLELEPIPEDS

TABLE A4
PRESENTED AREA RATIOS

FRAG NO. NEW	OLD	CD	MAX / MIN ICOS	CALC	MAX / AVG ICOS	CALC	AVG / MIN ICOS	CALC
1	2	0.42	1.00	1.00	1.00	1.00	1.00	1.00
2	95	0.50		3.04		1.22		2.48
3	3	0.64	1.54	1.73	1.13	1.15	1.36	1.50
4	70	0.71	2.10	5.99	1.22	1.39	1.73	4.32
5	44	0.72	1.69	5.05	1.20	1.39	1.41	3.63
6	62	0.73	1.56	9.49	1.16	1.50	1.34	6.33
7	53	0.76	1.65	8.16	1.20	1.49	1.38	5.48
8	41	0.76	1.44	5.94	1.20	1.47	1.19	4.03
9	11	0.76	2.42	9.53	1.45	1.53	1.67	6.21
10	57	0.78	2.10	6.05	1.31	1.45	1.60	4.18
11	35	0.79	3.36	14.41	1.55	1.58	2.17	9.09
12	90	0.79		6.20		1.37		4.51
13	45	0.80	1.55	5.91	1.34	1.43	1.46	4.14
14	89	0.80		6.24		1.35		4.64
15	82	0.81	2.27	7.08	1.43	1.52	1.58	4.66
16	40	0.82	2.77	7.52	1.23	1.44	2.26	5.21
17	13	0.83	1.72	4.67	1.26	1.42	1.37	3.29
18	46	0.83	2.03	6.81	1.29	1.46	1.57	4.67
19	18	0.83	2.11	10.35	1.37	1.46	1.54	7.03
20	73	0.84	3.24	8.60	1.59	1.58	2.03	5.44
21	76	0.84	4.28	9.13	1.75	1.56	2.44	5.85
22	63	0.86	3.50	14.36	1.51	1.62	2.33	8.86
23	33	0.86	1.66	5.49	1.24	1.39	1.33	3.96
24	74	0.86	2.27	9.01	1.43	1.50	1.59	6.00
25	39	0.86	2.50	9.37	1.47	1.61	1.70	5.82
26	65	0.86	2.49	8.18	1.42	1.42	1.75	5.77
27	47	0.87	1.76	7.81	1.30	1.49	1.35	5.24
28	69	0.87	2.27	10.50	1.39	1.55	1.63	6.78
29	55	0.88	2.63	11.81	1.42	1.56	1.86	7.58
30	64	0.88	3.76	15.99	1.69	1.70	2.22	9.42
31	12	0.88	2.38	7.92	1.52	1.62	1.56	4.90
32	27	0.89	2.20	9.87	1.37	1.53	1.60	6.44
33	83	0.89	3.25	8.56	1.56	1.62	2.08	5.28
34	78	0.90	2.21	14.62	1.43	1.54	1.54	9.51
35	32	0.90	2.81	13.35	1.31	1.52	2.15	8.78
36	60	0.90	1.99	5.80	1.32	1.43	1.50	4.05
37	4	0.91	1.90	7.46	1.23	1.50	1.54	4.99
38	67	0.92	2.33	12.10	1.50	1.58	1.56	7.65
39	68	0.92	1.94	7.66	1.33	1.48	1.47	5.16
40	85	0.93		10.07		1.53		6.59
41	72	0.93	3.41	14.75	1.66	1.69	2.05	8.75
42	9	0.93	2.71	10.05	1.41	1.55	1.93	6.48
43	1	0.94	2.19	6.92	1.29	1.30	1.70	5.33
44	17	0.94	2.63	11.01	1.45	1.55	1.82	7.13
45	88	0.95		17.53		1.64		10.69
46	43	0.95	2.59	26.57	1.41	1.71	1.84	15.50
47	16	0.95	2.75	15.71	1.35	1.54	2.04	10.17
48	[illegible]	0.96	2.52	14.44	1.37	1.53	1.84	9.42
49	31	0.96	1.66	5.69	1.23	1.40	1.35	4.06
50	29	0.96	1.97	8.34	1.33	1.49	1.48	5.58

TABLE A4 (CONTINUED)
PRESENTED AREA RATIOS

FRAG NO. NEW	OLD	CD	MAX / MIN ICOS	MAX / MIN CALC	MAX / AVG ICOS	MAX / AVG CALC	AVG / MIN ICOS	AVG / MIN CALC
51	37	0.96	2.84	8.97	1.41	1.54	2.02	5.85
52	61	0.96	3.16	16.18	1.61	1.68	1.96	9.66
53	14	0.96	2.41	7.71	1.34	1.49	1.79	5.19
54	10	0.97	3.04	16.34	1.61	1.73	1.89	9.47
55	87	0.98		14.53		1.62		8.99
56	71	0.98	3.71	15.58	1.63	1.65	2.28	9.45
57	15	0.98	2.06	7.26	1.34	1.52	1.54	4.76
58	38	0.98	2.26	7.70	1.43	1.50	1.57	5.13
59	42	0.98	2.08	8.33	1.36	1.46	1.53	5.69
60	75	0.99	3.24	10.72	1.50	1.53	2.17	6.98
61	96	0.99		5.27		1.45		3.63
62	91	0.99		12.36		1.62		7.64
63	81	0.99	2.67	11.97	1.34	1.54	2.00	7.77
64	84	1.00	3.23	18.65	1.57	1.65	2.06	11.33
65	93	1.01		15.97		1.64		9.72
66	94	1.02		7.41		1.46		5.06
67	23	1.02	2.25	6.98	1.35	1.47	1.67	4.74
68	59	1.03	3.43	10.55	1.68	1.63	2.04	6.49
69	56	1.03	3.87	16.68	1.48	1.57	2.61	10.64
70	48	1.04	2.45	7.25	1.44	1.54	1.70	4.69
71	51	1.05	2.62	12.55	1.35	1.53	1.95	8.19
72	7	1.05	2.89	8.80	1.36	1.53	1.54	5.75
73	6	1.06	2.62	8.94	1.39	1.53	1.89	5.83
74	66	1.0[illegible]	2.56	7.59	1.61	1.55	1.59	4.90
75	52	1.11	1.95	6.18	1.31	1.47	1.49	4.21
76	54	1.11	4.94	17.61	1.74	1.70	2.84	10.33
77	58	1.12	4.65	13.40	1.54	1.57	3.03	8.51
78	49	1.14	2.42	7.41	1.41	1.51	1.72	4.89
79	36	1.16	2.73	10.40	1.68	1.57	1.70	6.64
80	52	1.16	2.95	10.45	1.57	1.58	1.88	6.60
81	22	1.18	2.86	13.27	1.47	1.61	1.95	8.24
82	5	1.19	3.37	10.34	1.55	1.60	2.17	11.44
83	26	1.19	2.60	11.38	1.41	1.56	1.84	7.20
84	19	1.21	2.43	[illegible].55	1.45	1.52	1.68	4.98
85	86	1.24		15.79		1.64		9.63
86	30	1.24	2.49	11.65	1.43	1.50	1.74	7.75
87	77	1.29	3.64	15.13	1.51	1.59	2.42	9.50
88	34	1.29	2.69	9.50	1.38	1.55	1.94	6.12
89	20	1.29	2.77	11.41	1.41	1.59	1.97	7.16
90	25	1.30	3.05	11.51	1.50	1.57	2.04	7.35
91	79	1.31	3.04	13.58	1.60	1.63	1.90	8.32
92	28	1.33	2.26	8.46	1.40	1.50	1.61	5.64
93	8	1.34	3.17	14.32	1.55	1.67	2.05	8.57
94	21	1.38	3.72	14.29	1.56	1.63	2.38	8.77
95	92	1.42		19.91		1.69		11.77
96	2[illegible]	1.48	2.01	7.48	1.61	1.57	1.74	4.70

ICOS - PRESENTED AREA RATIOS CALCULATED FROM ICOSAHEDRON GAGE DATA
CALC - PRESENTED AREA RATIOS CALCULATED FROM APPROXIMATING RECTANGULAR PARALLELE-PIPEDS

TABLE A5
LINEAR AND STATISTICAL RATIOS

FRAG NO. NEW	FRAG NO. OLD	CD	L/T	W/T	L'/T'	W'/T'	SD / AAVG ICOS	SD / AAVG CALC	VAR / AAVG+2 ICOS	VAR / AAVG+2 CALC
1	2	0.42	(SPHERE)							
2	95	0.50	2.42	1.56	1.74	1.33		0.17		0.03
3	3	0.64	1.00	1.00	1.00	1.00	0.11	0.10	0.01	0.01
4	70	0.71	5.50	2.57	3.43	1.46	0.16	0.29	0.03	0.10
5	44	0.72	4.69	2.98	2.33	1.56	0.12	0.29	0.01	0.14
6	62	0.73	9.06	3.53	4.61	2.03	0.11	0.35	0.01	0.14
7	53	0.76	7.81	3.65	4.38	2.04	0.15	0.34	0.02	0.16
8	41	0.76	5.69	4.14	2.24	1.90	0.11	0.33	0.01	0.19
9	11	0.76	9.22	4.19	5.50	3.11	0.25	0.37	0.06	0.36
10	57	0.78	5.74	3.53	4.11	2.53	0.20	0.32	0.04	0.13
11	35	0.79	14.02	4.43	8.36	2.81	0.34	0.39	0.12	0.21
12	90	0.79	5.63	2.34	4.42	2.66		0.21		0.08
13	45	0.80	5.57	3.25	3.55	2.31	0.18	0.31	0.03	0.15
14	89	0.80	5.50	1.98	3.57	1.68		0.26		0.07
15	82	0.81	6.86	4.71	4.03	3.18	0.26	0.36	0.07	0.11
16	40	0.82	7.08	3.03	3.86	1.80	0.20	0.32	0.04	0.16
17	13	0.83	4.41	3.78	2.55	2.34	0.16	0.30	0.03	0.30
18	46	0.83	6.48	3.49	3.73	2.59	0.22	0.33	0.05	0.16
19	18	0.83	9.69	2.77	5.70	2.29	0.21	0.33	0.05	0.26
20	73	0.84	8.42	5.79	5.06	3.92	0.34	0.39	0.11	0.13
21	76	0.84	8.90	4.94	5.58	3.19	0.29	0.38	0.15	0.12
22	63	0.86	14.09	5.37	7.85	3.38	0.32	0.41	0.10	0.16
23	33	0.86	5.08	2.77	3.40	2.50	0.15	0.29	0.02	0.16
24	74	0.86	8.63	3.63	4.24	2.23	0.24	0.35	0.06	0.11
25	39	0.86	9.20	6.37	5.43	4.05	0.28	0.40	0.20	0.22
26	65	0.86	7.55	2.52	5.43	2.33	0.25	0.30	0.06	0.11
27	47	0.87	7.49	3.74	3.49	1.86	0.17	0.34	0.03	0.17
28	69	0.87	10.18	4.29	6.38	3.08	0.23	0.37	0.05	0.14
29	55	0.88	11.45	4.22	6.71	2.47	0.27	0.38	0.07	0.16
30	64	0.88	15.84	7.92	6.32	4.14	0.41	0.45	0.17	0.17
31	12	0.88	7.79	7.79	4.55	4.15	0.30	0.41	0.09	0.41
32	27	0.89	9.54	4.09	5.10	2.48	0.23	0.37	0.05	0.24
33	[illegible]	0.89	8.43	7.37	5.70	5.07	0.37	0.41	0.13	0.12
34	8	0.90	14.02	3.51	7.74	2.55	0.23	0.37	0.05	0.10
35	32	0.90	12.75	3.36	6.19	2.09	0.22	0.36	0.05	0.20
36	60	0.90	5.47	3.37	3.35	2.04	0.19	0.31	0.04	0.13
37	4	0.91	7.17	3.98	2.97	1.79	0.17	0.35	0.03	0.38
38	67	0.92	11.79	4.72	7.23	3.27	0.26	0.39	0.07	0.15
39	60	0.92	7.33	3.66	5.01	2.82	0.23	0.34	0.05	0.13
40	85	0.93	9.72	3.96	7.08	2.83		0.36		0.13
41	[illegible]	0.93	14.59	7.64	9.66	5.41	0.39	0.44	0.15	0.14
42	5	0.93	9.76	4.44	5.81	2.68	0.27	0.37	0.07	0.38
43	1	0.94	5.17	1.15	5.16	1.15	0.21	0.23	0.04	0.14
44	17	0.94	10.65	4.10	5.84	2.56	0.26	0.37	0.07	0.32
45	80	0.95	17.21	5.44	10.86	4.31		0.42		0.17
46	43	0.95	26.29	7.00	10.33	5.33	0.23	0.45	0.05	0.19
47	16	0.95	15.10	3.55	8.76	2.42	0.25	0.37	0.06	0.30
48	88	0.96	13.84	3.46	8.05	2.22	0.24	0.37	0.06	0.10
49	31	0.96	5.29	2.89	3.17	2.18	0.15	0.29	0.02	0.17
50	29	0.96	7.99	3.69	4.94	2.47	0.20	0.35	0.04	0.22

TABLE A5 (CONTINUED)
LINEAR AND STATISTICAL RATIOS

FRAG NO. NEW	FRAG NO. OLD	CD	L/T	W/T	L'/T'	W'/T'	SD / AAVG ICOS	SD / AAVG CALC	VAR / AAVG+2 ICOS	VAR / AAVG+2 CALC
51	37	0.96	8.69	4.35	5.61	2.86	0.25	0.37	0.06	0.20
52	61	0.96	15.98	6.85	9.11	3.89	0.35	0.43	0.12	0.17
53	14	0.96	7.37	3.69	4.30	2.68	0.22	0.34	0.05	0.33
54	10	0.97	16.22	9.46	9.12	4.83	0.35	0.46	0.12	0.43
55	87	0.98	14.23	5.18	7.65	3.64		0.41		0.17
56	71	0.98	15.34	6.00	9.74	3.72	0.36	0.42	0.13	0.14
57	15	0.98	7.03	4.69	4.29	3.04	0.21	0.36	0.05	0.35
58	38	0.98	7.41	3.99	5.11	2.81	0.25	0.35	0.06	0.19
59	42	0.98	7.88	3.15	5.98	2.33	0.19	0.33	0.04	0.17
60	75	0.99	10.34	3.94	6.66	2.91	0.28	0.37	0.08	0.12
61	96	0.99	5.02	4.06	3.34	2.73		0.32		0.10
62	91	0.99	12.13	5.66	8.91	4.58		0.41		0.17
63	81	0.99	11.55	3.85	7.57	2.77	0.22	0.37	0.05	0.11
64	84	1.00	15.33	5.50	10.09	3.32	0.33	0.42	0.11	0.11
65	93	1.01	15.70	5.74	12.05	4.83		0.42		0.18
66	94	1.02	7.04	3.40	5.27	2.86		0.33		0.11
67	23	1.02	6.66	3.63	4.46	2.44	0.22	0.33	0.05	0.24
68	59	1.03	10.38	6.49	6.57	4.88	0.38	0.41	0.14	0.17
69	56	1.03	16.12	3.87	10.00	2.59	0.29	0.38	0.03	0.15
70	48	1.04	7.05	5.29	4.09	3.38	0.28	0.37	0.08	0.19
71	51	1.05	12.06	3.62	6.30	1.83	0.24	0.36	0.06	0.16
72	7	1.05	8.51	4.25	5.19	2.84	0.23	0.36	0.05	0.39
73	6	1.06	8.66	4.33	5.53	3.23	0.24	0.37	0.06	0.40
74	66	1.06	7.39	5.28	5.21	3.80	0.30	0.37	0.09	0.15
75	50	1.11	5.91	3.94	2.82	2.18	0.19	0.33	0.04	0.16
76	54	1.11	17.44	7.65	10.63	5.36	0.43	0.45	0.10	0.19
77	58	1.12	13.02	4.74	6.06	2.47	0.30	0.39	0.09	0.16
78	49	1.14	7.16	4.40	4.25	2.70	0.25	0.36	0.06	0.10
79	36	1.16	10.13	4.73	6.26	2.95	0.29	0.38	0.08	0.21
80	52	1.16	10.21	5.10	5.86	3.36	0.34	0.39	0.12	0.18
81	22	1.18	12.93	5.20	8.04	3.01	0.29	0.40	0.08	0.28
82	5	1.19	17.87	4.47	11.12	2.94	0.31	0.40	0.10	0.39
83	26	1.19	11.05	4.42	5.46	2.55	0.26	0.38	0.07	0.24
84	19	1.21	7.30	4.38	4.99	3.38	0.28	0.36	0.08	0.31
85	86	1.24	15.52	5.64	10.07	4.75		0.42		0.17
86	30	1.24	11.10	3.27	6.84	2.52	0.24	0.35	0.06	0.21
87	77	1.29	14.74	4.54	9.36	3.11	0.33	0.49	0.11	0.12
88	34	1.29	9.24	4.62	4.09	2.69	0.22	0.38	0.05	0.22
89	20	1.29	11.15	5.15	5.61	2.92	0.23	0.40	0.05	0.31
90	25	1.30	11.19	4.48	7.10	3.33	0.32	0.38	0.10	0.25
91	79	1.31	13.35	5.80	7.76	3.65	0.32	0.41	0.10	0.12
92	28	1.33	8.12	3.75	4.19	2.16	0.22	0.35	0.05	0.22
93	6	1.34	14.15	7.07	8.45	4.78	0.33	0.43	0.11	0.43
94	21	1.38	14.04	5.61	8.49	3.56	0.34	0.41	0.12	0.30
95	92	1.42	19.67	6.86	11.16	5.31		0.44		0.20
96	24	1.48	7.31	5.85	5.22	4.28	0.34	0.38	0.12	0.28

HEADINGS
L - AVERAGE LENGTH   W - AVERAGE WIDTH   T - AVERAGE THICKNESS
L' = MAXIMUM LENGTH PLUS AVERAGE LENGTH
W' = MAXIMUM WIDTH PLUS AVERAGE WIDTH
T' = MAXIMUM THICKNESS PLUS AVERAGE THICKNESS
SD - STANDARD DEVIATION OF PRESENTED AREAS (SQ. IN.)
VAR - VARIANCE OF PRESENTED AREAS (IN. 4TH)
AAVG+2 - AVERAGE PRESENTED AREA SQUARED (IN. 4TH)
ICOS - AREAS CALCULATED FROM ICOSAHEDRON GAGE DATA
CALC - AREAS CALCULATED FROM APPROXIMATING RECTANGULAR PARALLELAEPIPEDS

TABLE A6
PERIMETER RATIOS

FRAG NO. NEW	FRAG NO. OLD	CD	LWP/LTP	LWP/TWP	LTP/TWP	LWP/LMAX	TWP/WMAX
1	2	0.42	1.00	1.00	1.00	3.14	3.14
2	95	0.50	1.03	1.18	1.08	3.04	2.91
3	3	0.64	1.00	1.00	1.00	4.03	4.03
4	70	0.71	1.01	2.03	2.00	2.42	3.03
5	44	0.72	1.08	1.47	1.36	2.83	2.74
6	62	0.73	1.25	1.98	1.58	3.04	3.12
7	53	0.76	1.12	2.14	1.91	2.81	2.84
8	41	0.76	1.05	1.07	1.02	2.57	2.47
9	11	0.76	1.22	1.87	1.54	2.70	2.11
10	57	0.78	1.07	1.70	1.59	2.33	2.22
11	35	0.79	1.10	2.42	2.21	2.29	2.66
12	90	0.79	1.07	1.74	1.63	2.28	1.71
13	45	0.80	1.10	1.50	1.36	2.52	2.37
14	89	0.80	1.01	1.48	1.47	2.22	2.60
15	82	0.81	1.37	1.42	1.03	2.90	2.31
16	40	0.82	1.00	1.90	1.90	2.21	2.32
17	13	0.83	1.16	1.19	1.03	2.78	2.43
18	46	0.83	1.25	1.69	1.36	2.82	1.97
19	18	0.83	1.11	1.69	1.52	2.25	2.55
20	73	0.84	1.36	1.68	1.23	3.11	2.15
21	76	0.84	1.17	1.69	1.44	2.39	2.42
22	63	0.86	1.09	2.57	2.35	2.41	1.96
23	33	0.86	1.18	1.35	1.15	2.40	1.95
24	74	0.86	1.16	1.54	1.33	2.53	2.59
25	39	0.86	1.62	1.70	1.04	3.21	2.38
26	65	0.86	1.18	2.29	1.93	2.58	2.13
27	47	0.87	1.24	1.68	1.35	2.68	2.82
28	69	0.87	1.14	2.25	1.97	2.57	2.10
29	55	0.88	1.11	2.89	2.59	2.40	2.25
30	64	0.88	1.67	1.96	1.17	3.26	2.04
31	12	0.88	1.38	1.57	1.14	2.93	2.22
32	27	0.89	1.11	2.34	2.11	2.47	1.96
33	83	0.89	1.54	1.63	1.05	3.23	2.20
34	78	0.90	1.21	2.58	2.13	2.61	2.48
35	32	0.90	1.03	2.09	2.03	2.17	2.52
36	68	0.90	1.06	1.53	1.45	2.36	2.56
37	4	0.91	1.09	1.36	1.25	2.56	2.92
38	67	0.92	1.29	2.34	1.81	2.62	2.25
39	60	0.92	1.04	1.06	1.02	2.27	3.44
40	85	0.93	1.16	2.78	2.40	2.42	2.21
41	72	0.93	1.31	2.05	1.57	2.57	2.12
42	9	0.93	1.14	2.04	1.79	2.47	2.59
43	1	0.94	1.02	2.88	2.82	2.52	3.92
44	17	0.94	1.14	2.00	1.75	2.34	2.38
45	80	0.95	1.16	2.44	2.10	2.37	2.05
46	43	0.95	1.16	3.74	3.22	2.68	2.31
47	16	0.95	1.05	2.46	2.33	2.12	2.73
48	88	0.96	1.09	3.03	2.77	2.33	2.55
49	31	0.96	1.10	1.31	1.18	2.56	2.34
50	29	0.96	1.04	1.96	1.88	2.31	2.20

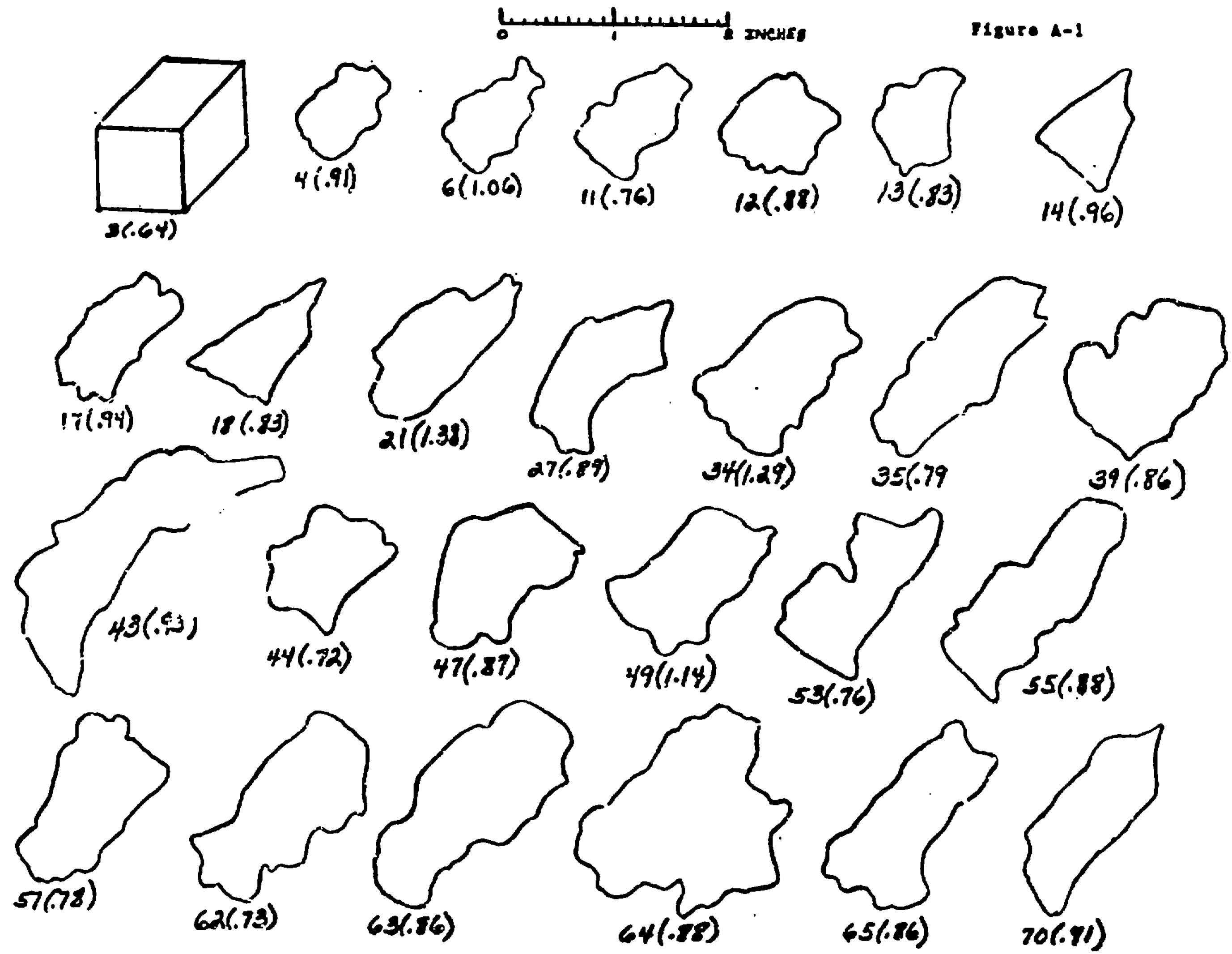
TABLE A6 CONTINUED
PERIMETER RATIOS

FRAG NO. NEW	FRAG NO. OLD	CD	LWP/LTP	LWP/TWP	LTP/TWP	LWP/LMAX	TWP/WMAX
51	37	0.96	1.13	1.99	1.76	2.37	2.29
52	61	0.96	1.12	2.46	2.19	2.30	2.20
53	14	0.96	1.25	1.48	1.19	2.88	2.59
54	10	0.97	1.45	2.29	1.59	2.32	2.08
55	87	0.98	1.35	2.41	1.78	2.52	1.80
56	71	0.98	1.15	2.85	2.46	2.36	2.22
57	15	0.98	1.16	1.63	1.41	2.70	2.22
58	38	0.98	1.08	1.90	1.76	2.23	2.10
59	42	0.98	1.08	2.43	2.25	2.46	2.65
60	75	0.99	1.10	2.07	1.88	2.41	2.51
61	96	0.99	1.39	1.58	1.14	2.92	2.29
62	91	0.99	1.42	2.29	1.61	2.69	2.11
63	81	0.99	1.00	2.64	2.64	2.32	2.20
64	84	1.00	1.36	3.41	2.52	2.64	2.16
65	93	1.01	1.31	3.95	3.02	2.85	1.67
66	94	1.02	1.26	1.03	1.45	2.70	2.48
67	23	1.02	1.14	1.66	1.[illegible]	2.33	2.58
68	59	1.03	1.54	1.64	1.06	3.04	2.16
69	56	1.03	1.03	3.25	3.14	2.14	2.38
70	40	1.04	1.39	1.42	1.02	2.90	2.28
71	51	1.05	1.03	2.89	2.81	2.16	2.64
72	7	1.05	1.20	1.79	1.50	2.66	2.50
73	6	1.06	1.20	1.71	1.42	2.51	2.21
74	66	1.06	1.47	1.60	1.09	2.78	2.34
75	50	1.11	1.26	1.44	1.15	3.29	2.59
76	54	1.11	1.22	2.10	1.72	2.51	2.16
77	58	1.12	1.13	2.14	1.89	2.37	2.30
78	49	1.14	1.35	1.88	1.40	2.98	2.42
79	36	1.16	1.09	2.14	1.97	2.23	2.19
80	52	1.16	1.34	1.92	1.43	2.67	2.16
81	22	1.18	1.00	2.78	2.78	2.17	2.22
82	5	1.19	1.04	2.90	2.80	2.10	2.60
83	26	1.19	1.27	2.22	1.75	2.62	2.22
84	19	1.21	1.32	1.66	1.26	2.87	2.28
85	86	1.24	1.31	2.10	1.61	2.61	2.15
86	30	1.24	1.09	2.25	2.07	2.26	2.27
87	77	1.29	1.19	2.74	2.31	2.30	2.35
88	34	1.29	1.19	1.91	1.61	2.64	2.31
89	20	1.29	1.20	1.87	1.55	2.36	2.21
90	25	1.30	1.24	1.84	1.48	2.36	2.40
91	79	1.31	1.41	2.65	1.88	2.82	2.12
92	20	1.33	1.06	1.70	1.61	2.54	2.64
93	8	1.34	1.18	1.86	1.57	2.52	2.16
94	21	1.38	1.11	2.30	2.07	2.21	2.20
95	92	1.42	1.38	2.20	1.60	2.72	2.07
96	24	1.48	1.34	1.64	1.23	2.98	2.16

HEAD;NOS
LWP - PERIMETER IN LW PLANE (IN.)
LTP - PERIMETER IN LT PLANE (IN.)
TWP - PERIMETER IN TW PLANE (IN.)
LMAX - MAXIMUM LENGTH (IN.)
WMAX - MAXIMUM WIDTH (IN.)

RANDOM TUMBLING

Figure A-1



RANDOM TUMBLING

0 1 2 INCHES

Figure A-1 (Cont'd)

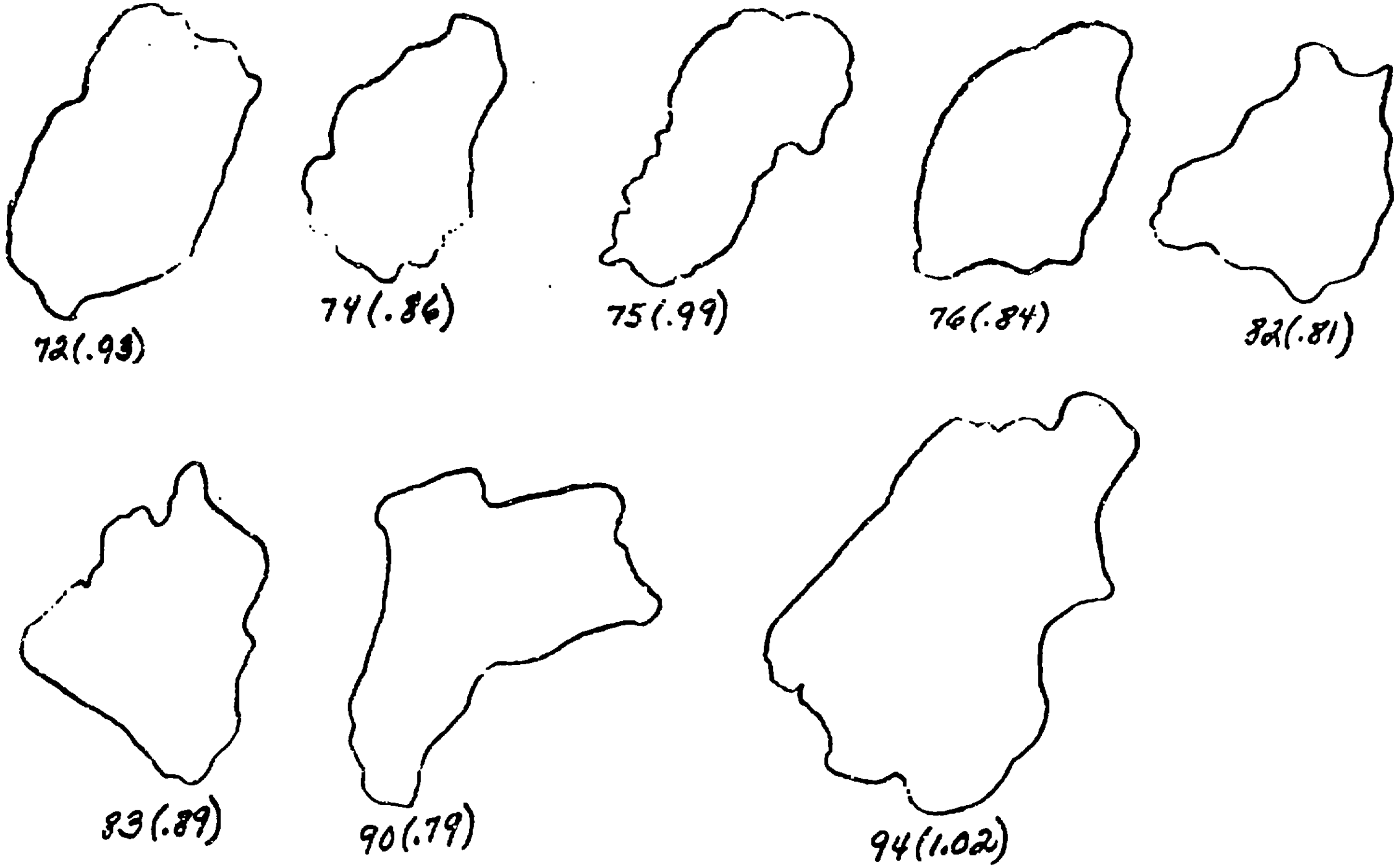


Figure A-2

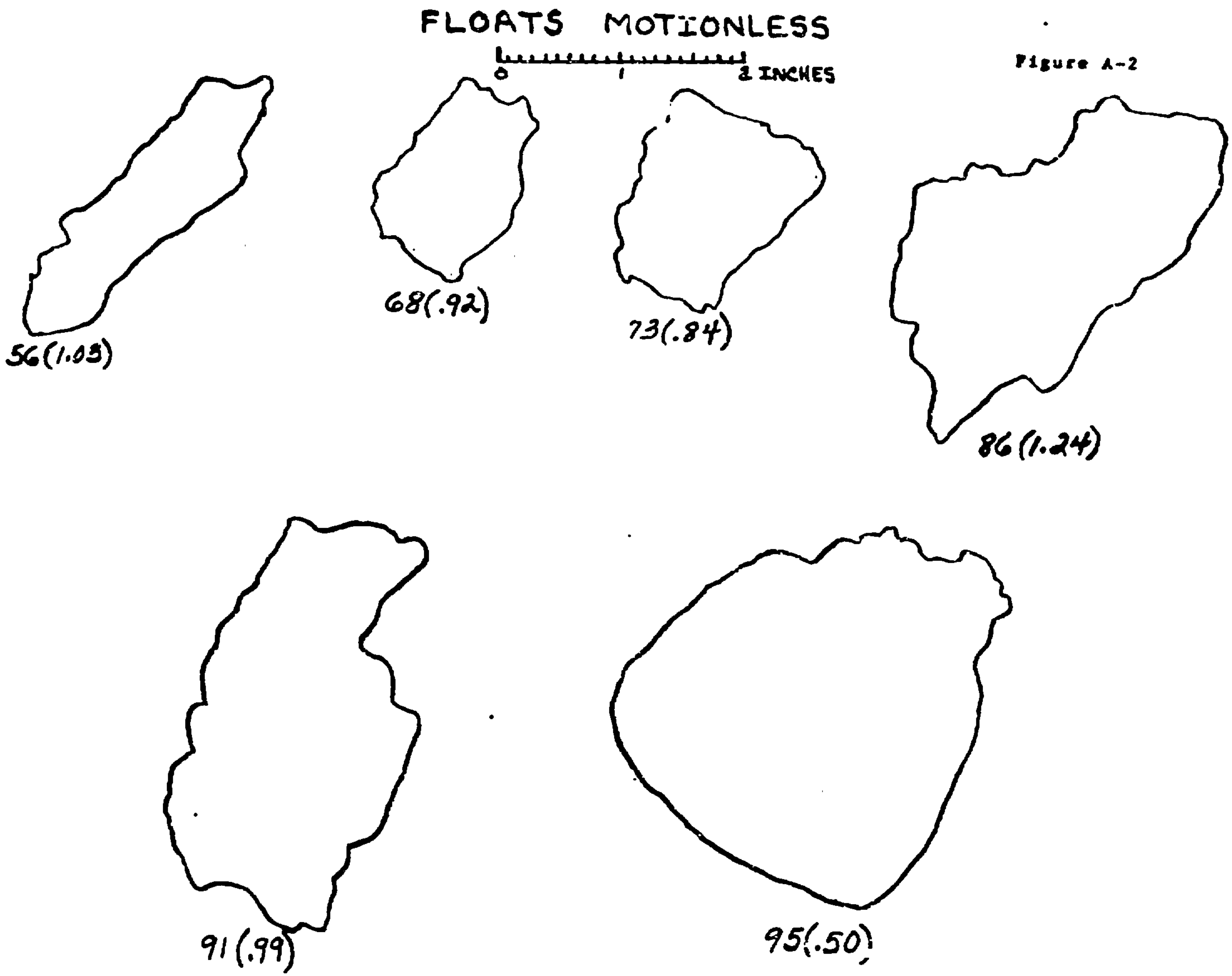
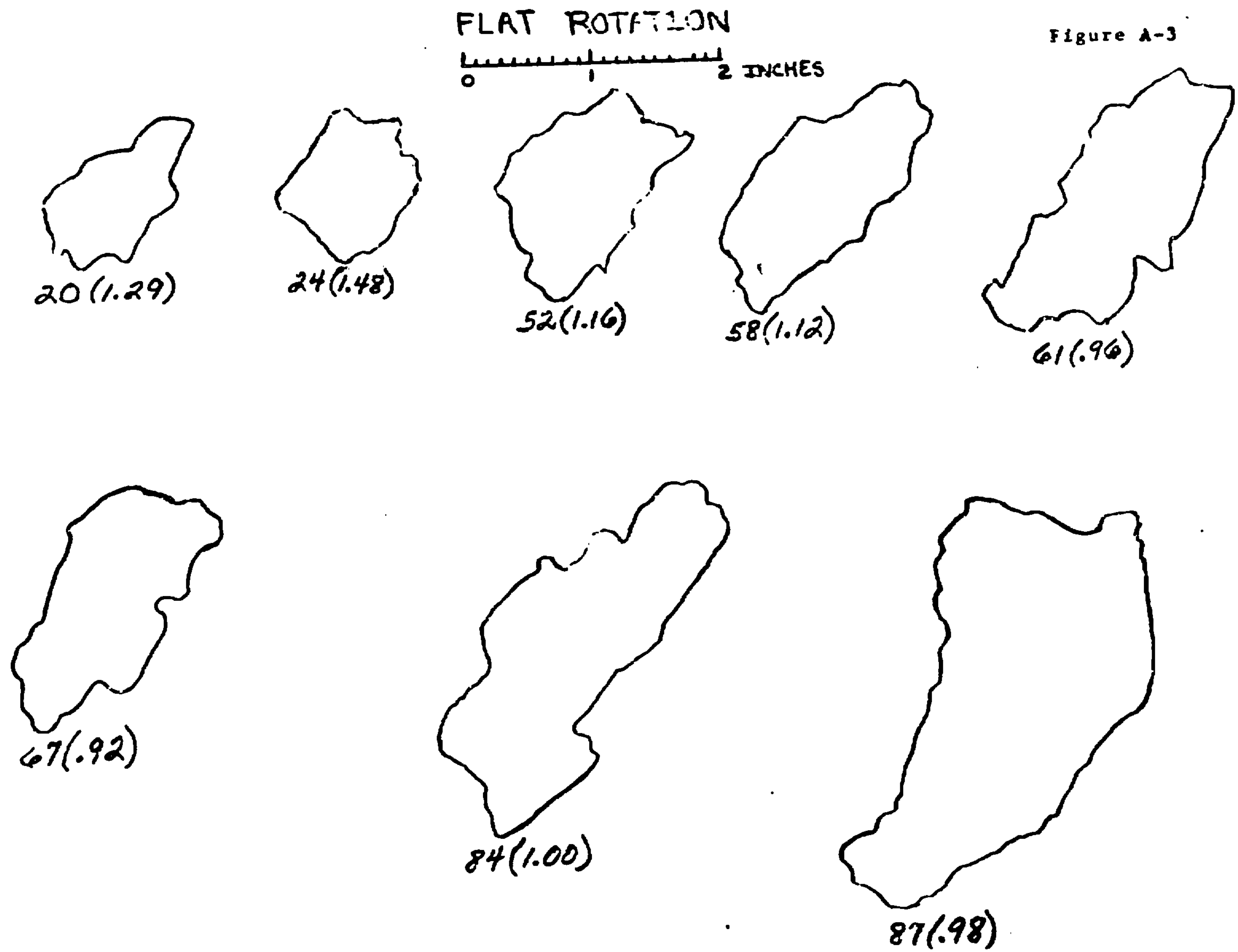

FLOATS MOTIONLESS
0
1
2 INCHES
56(1.03)
68(.92)
73(.84)
86(1.24)
91(.99)
95(.50)

Figure A-3


FLAT ROTATION
0
1
2 INCHES
20(1.29)
24(1.48)
52(1.16)
58(1.12)
61(.96)
67(.92)
84(1.00)
87(.98)

ROTATES ABOUT THE LYT AXIS

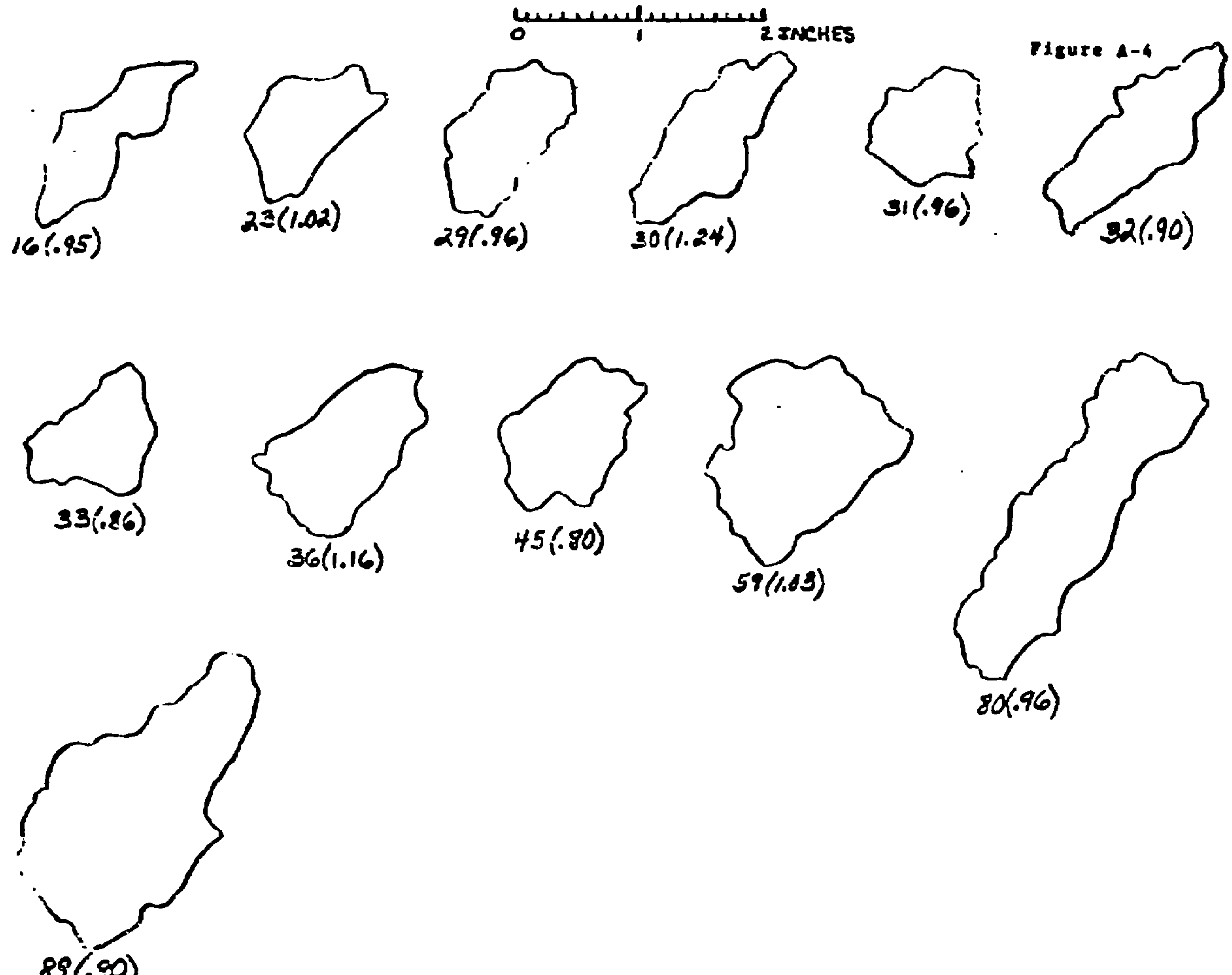
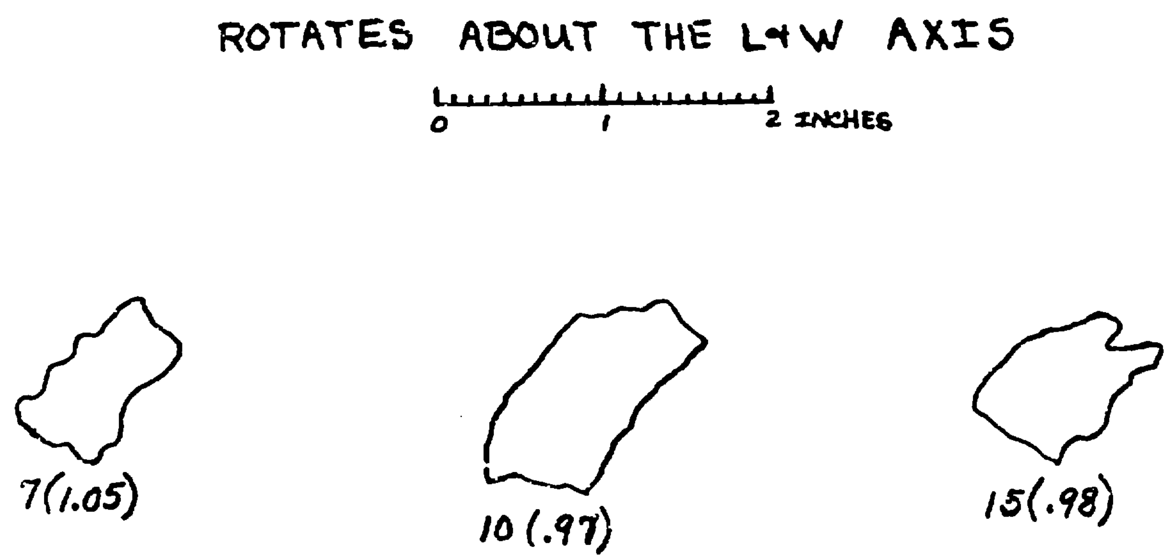


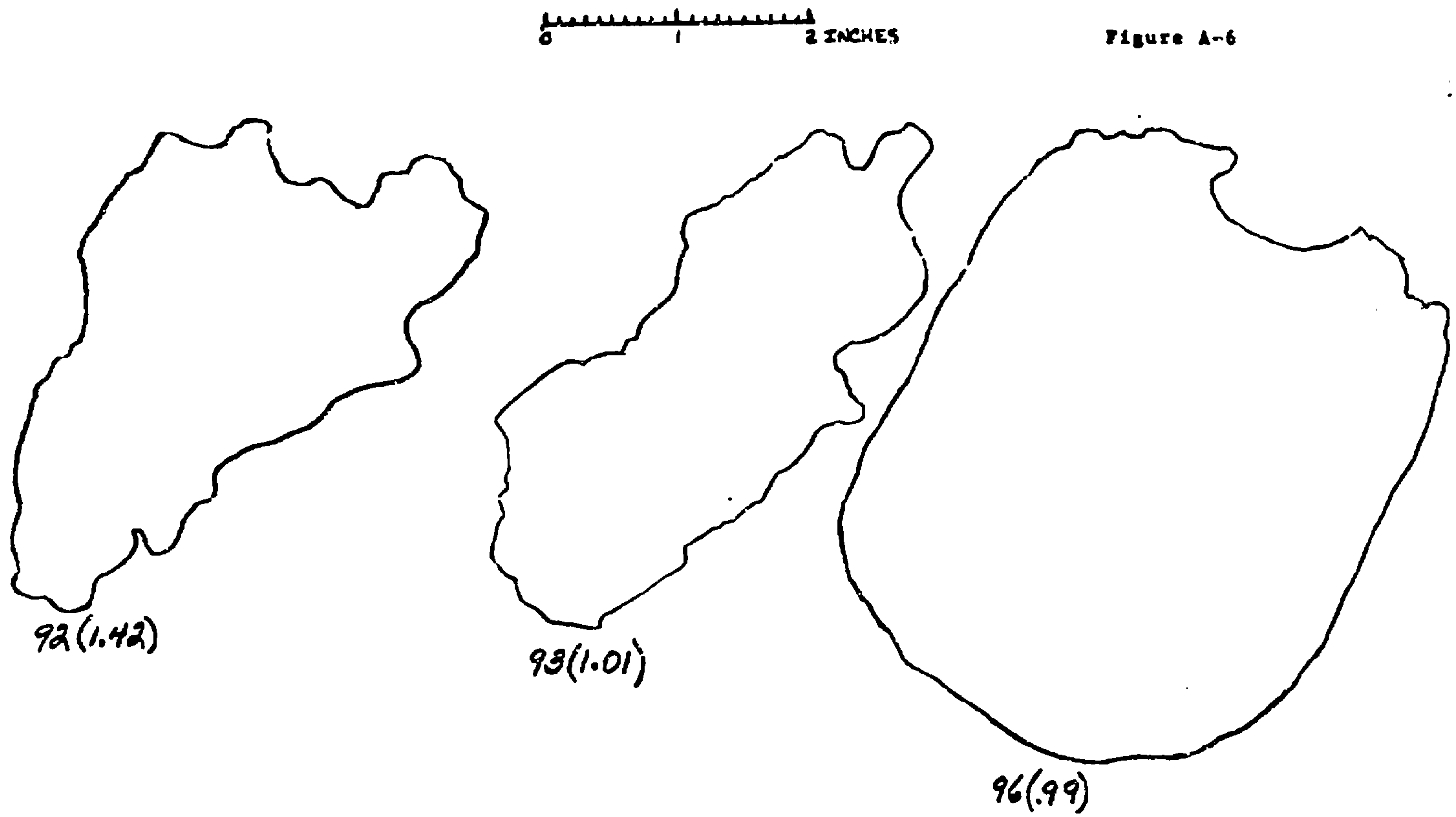
Figure A-4

Figure A-5



ROTATES AROUND THE T-AXIS

Figure A-6



ROTATES AROUND THE T-AXIS

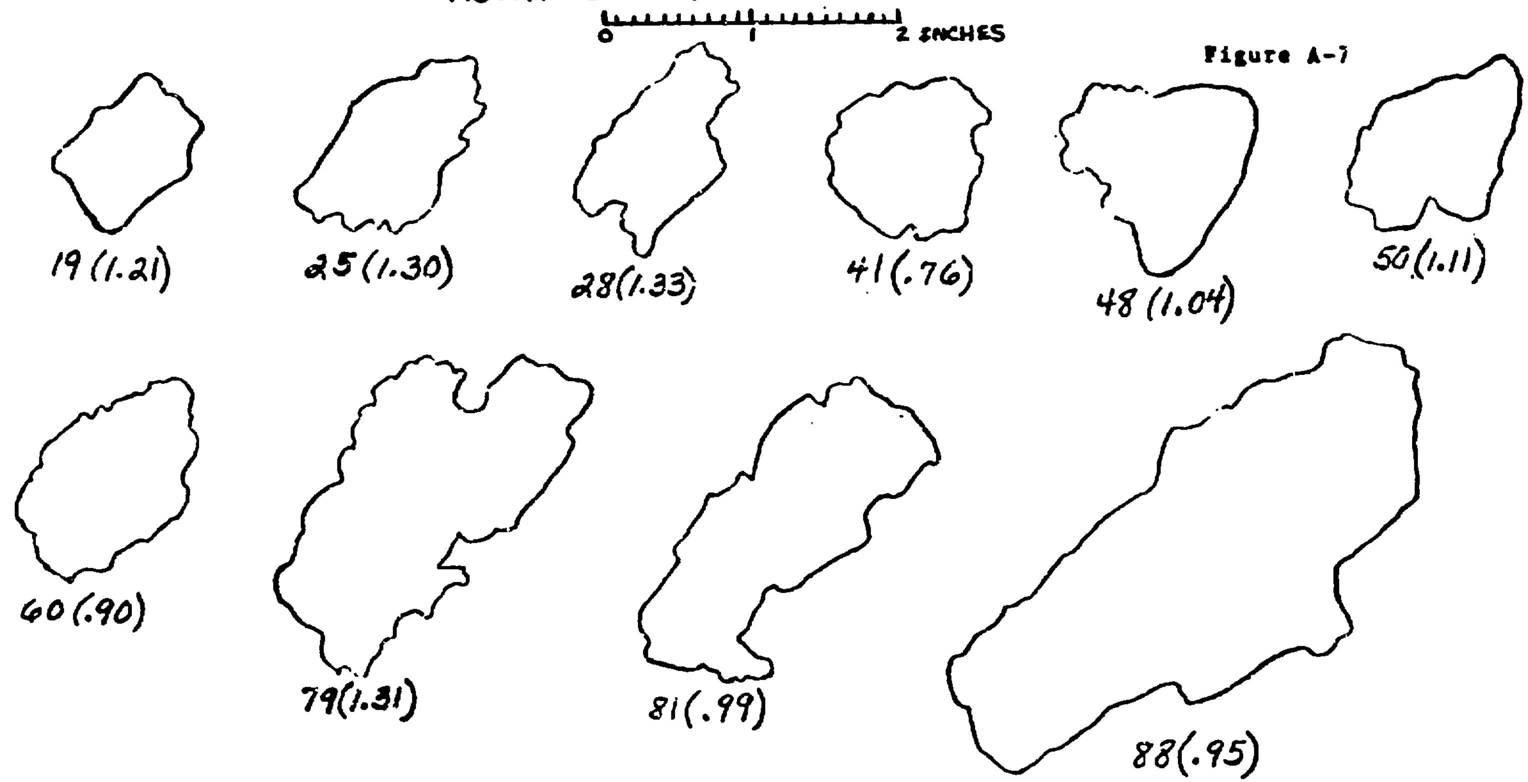
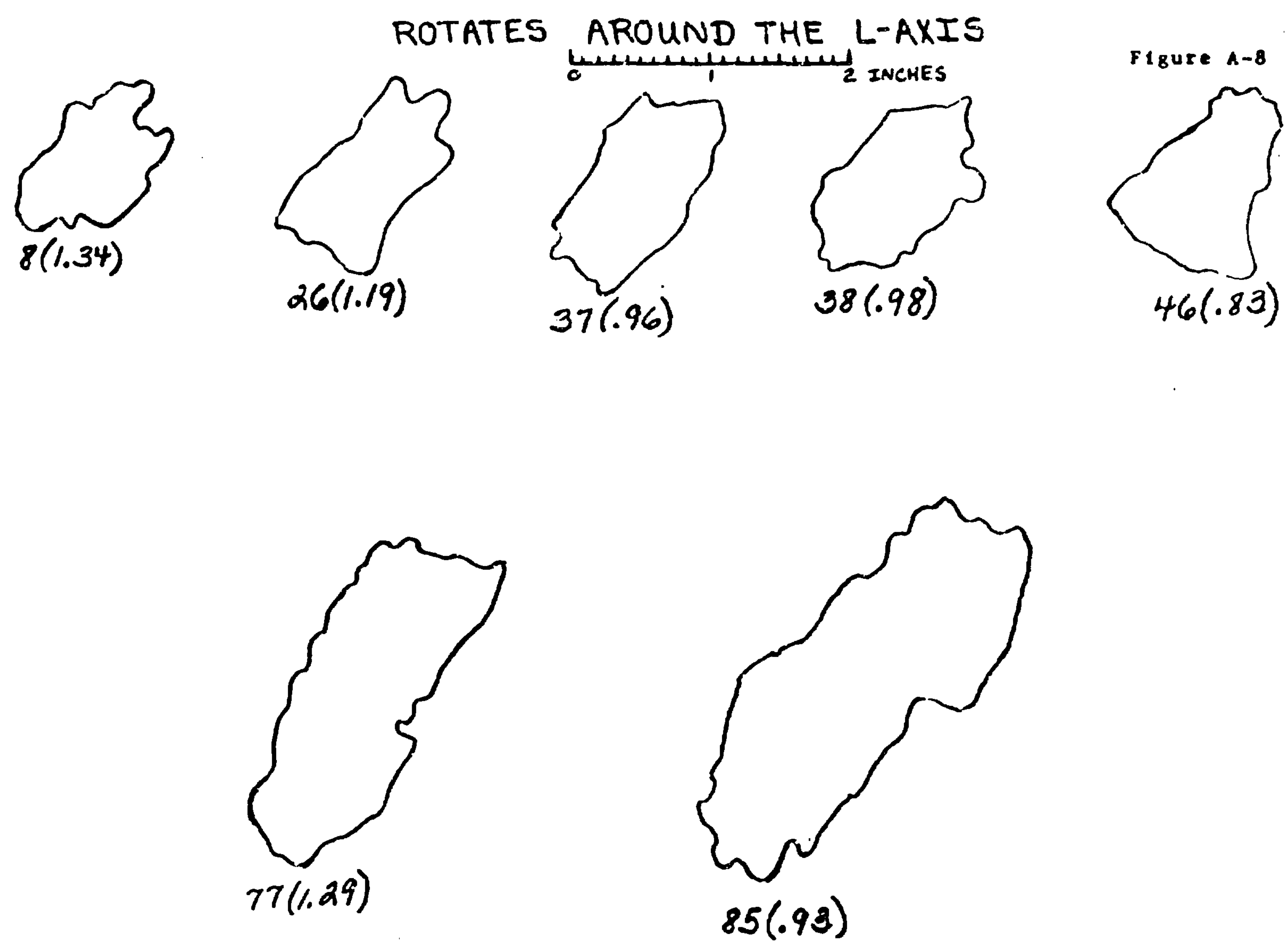


Figure A-7

Figure A-8



ROTATES AROUND THE L-AXIS
0
1
2 INCHES
8(1.34)
26(1.19)
37(.96)
38(.98)
46(.83)
77(1.29)
85(.93)

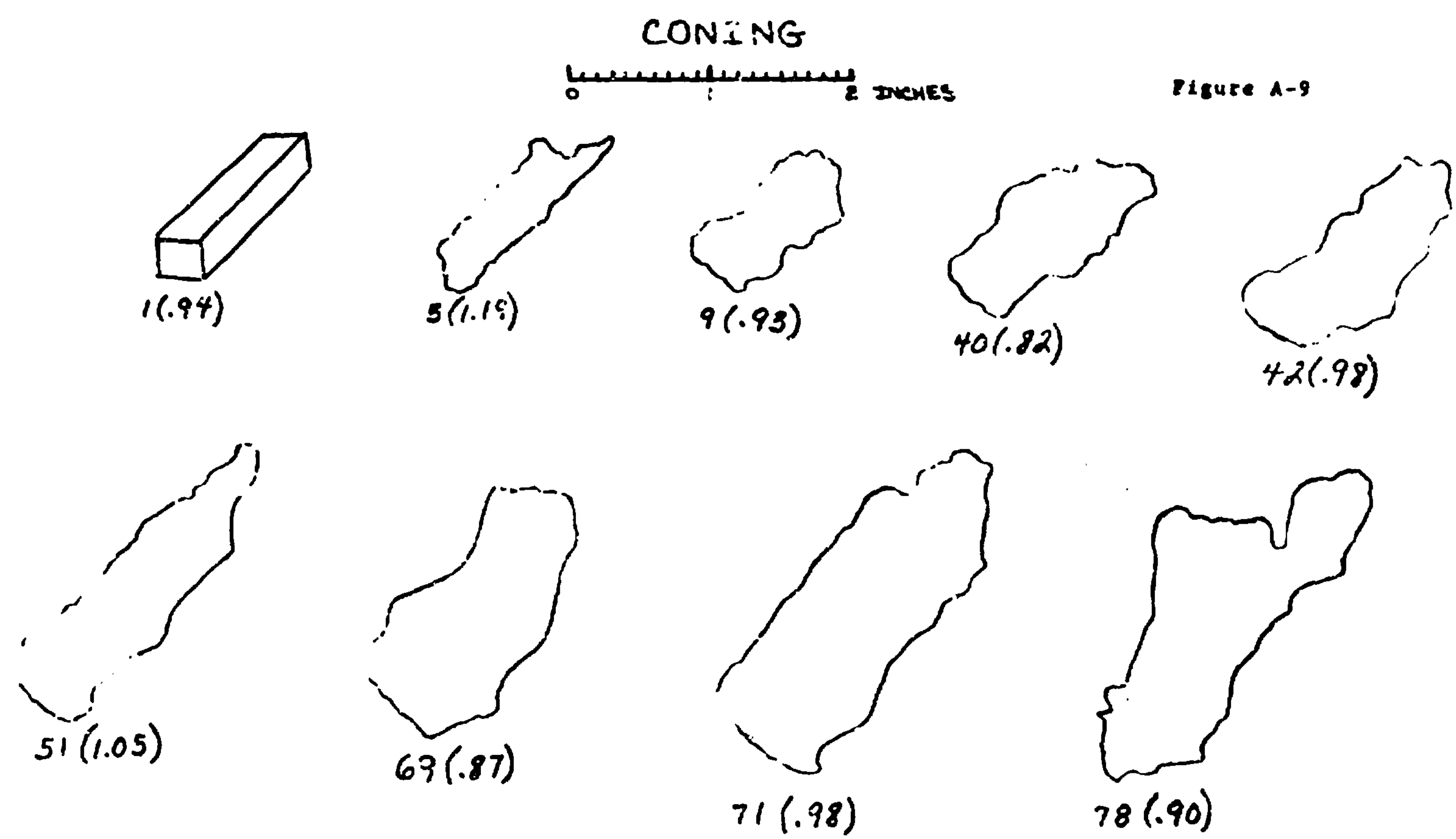


Figure A-9